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The Engineering News Book Dept.

BY

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esign and Mechanical Drawing, Carnegie Technical Schools, Pittsburg
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PREFACE

In a paper on "Mechanical Drawing in the Modern Drafting Room" read before the Engineers' Society of Western Pennsylvania, in June, 1903, I dwelt with some emphasis upon the importance of uniformity in what I then termed the "dictionary" features of mechanical drawings. This paper was reprinted by the Society as a pamphlet, and later was published in *Engineering News* and in several other of the leading engineering periodicals both here and in England. The great interest taken in the subject was entirely unexpected. In all, something over seventy letters were received containing favorable comments, letters not only from all parts of the United States but from Canada, England, France, Holland, and even from New Zealand and South Africa. Among these letters were several from universities and colleges asking if it were not possible to put together a "drawing dictionary" as a text-book for the use of our schools and colleges. It seemed to be the unanimous opinion that such a dictionary, dealing with mechanical drawing as a language, would be appreciated by teachers, students, and drafting rooms alike. Finally the editor of *Engineering News* suggested that I prepare such a dictionary to be published first in that journal and afterwards as a text-book. This book is the result of that suggestion. It has been written with the hope that the drafting fraternity, as well as teachers and students of mechanical drawing, will accept it, as far as it goes, and use it as a basis for the writing of the language.

The author has for many years believed that such a book should be written to insure reasonable uniformity in the drawings made by different men in different places.

G. H. F.

August 15, 1906.

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CHAPTER I. INTRODUCTION AND AN ALPHABET.

SOME two thousand four hundred years ago a philosopher and historian known to the world as Diogenes of Apollonia said: "It appears to me that he who begins a treatise ought to lay down principles about which there can be no dispute."

2. As this article is the first of a series, and is written with a hope that the complete series will result in an acceptable "drawing dictionary" for general use, it seems only right to begin by laying down the principles upon which the character of the dictionary is to depend. I do not presume to think that the principles are new or that I am able to lay them down in such a way as to leave no room for dispute; but, believing that the manner of presenting a subject is fully as important as the subject itself, it seems best to begin in this way so that those who read the series critically may stand on common ground and, looking at each feature from the same general position, pool their ideas to some useful purpose.

3. *Mechanical drawing is a "language."*

This is the first principle that I would lay down, and it is the general one upon which arguments will be based and in keeping with which criticisms should be made; it means that mechanical drawing can be compared with any other language, English, for instance; for although it cannot be spoken or heard, it can be both written and read, written well and read well, written badly and read badly. And, just as the ability to write or read (that is, understand) good English depends upon a knowledge of English as a language, so the ability to make or read a good drawing depends upon a knowledge of drawing as a language.

4. When we think of English as a language, we have in mind an alphabet, words, and sentences; and going further to the written language as we find it in our libraries, we add chapters and books.

5. *There is a broad and useful analogy between mechanical drawing as a language and English as a language.*

6. This is the second principle that I would lay down. There are many ways of expressing the analogy, but the following is sufficiently suggestive and will suffice for the present:

Lines are analogous to	Letters
Views to	Words
Projected views to	Sentences
Drawings to	Chapters
Sets of drawings to	Books

Lines should be varied in weight and size to suit the character of drawing.

OUTLINE	Heavy	For the visible bounding lines of a view.
HIDDEN LINE	Medium	For the hidden bounding lines of a view.
CENTER LINE	Thin	For indicating the position of an imaginary unbroken line of no thickness.
DIMENSION LINE	Thin	For indicating the path of a dimension, and the points or surfaces between which measurement is to be made.
PROJECTION LINE	Thin	For projecting a dimension line to a convenient position clear of a view; also for projecting in general.
BREAK LINES	Heavy #1 / Uneven #2	For indicating that for convenience some part of a view is broken away: #1. For all materials except when #2 is preferable for wood broken across the grain.
PATH LINE	Thin	For indicating a path of motion.
DITTO LINE	Medium	For indicating a uniform repetition or continuation of some shape when a completed layout is not necessary and would be expensive.
SUB LINE	Medium	For indicating either an alternative position of the same piece or the bounding lines of a substitute piece.
ADJACENT LINE	Medium	For the bounding lines of what is adjacent to a view.
ALLOWANCE LINE	Medium	For indicating a special allowance for finish.
LIMIT LINE	Very heavy	For indicating a surface or position beyond which nothing should project.
CUTTING LINES	Medium #1 / Very heavy #2	For indicating the position of a cutting plane in connection with a sectional view: #1. When the plane does not coincide with a center line. #2. When the plane coincides with a center line; also when it is not desirable to have the line passing through a view.

Special Lines: When a line is used for a special purpose, (except when conventional) there should be a note explaining its meaning.

Broken Lines: There should be clear space between the parts of all broken lines; otherwise they have too nearly the appearance of full lines.

FIG. 1. THE ALPHABET OF LINES.

7. Teachers and students alike should make practical use of this principle, as inducing a true conception of the relative values of the parts of drawings, and as enabling the subject as a language to be studied and taught intelligently.

8. Knowledge of English is obtained from books written with the express purpose of teaching it as a language, beginning with an alphabet of letters and the spelling of words, and ending with the teachings of scholars and thinkers from whose writings we receive instruction regarding the construction of sentences and the arrangement of ideas, as from the late Herbert Spencer's "Philosophy of Style."

9. So far as English is concerned, the result of having an accepted dictionary and the carefully written teachings of scholars is that books written by one man can be read and understood without difficulty by other men, and that there is general uniformity about the mechanical features of all real books. By mechanical features I mean the type, the page numbering, the division into chapters, the insertion of illustrations, the position and general arrangement of title page, the index to contents, and the "build" of the book itself. So that when we compare two English books, even though they are by different authors and were printed in different countries, we find the same alphabet, the same spelling, sentences of similar form, the same rules of composition followed, and in general the same mechanical features, both inside and out. The advantage of this uniformity is twofold: The reader can turn from one book to another without being confused by differences in spelling, word meanings or general arrangement; and books can be placed side by side on the same shelf without offending our sense of what is reasonable.

10. The object of the proposed drawing dictionary is to bring about a similar state of things in connection with mechanical drawings.

11. At the present time, there being no generally adopted dictionary, our universities, colleges and schools teach almost as many drawing languages (or rather "dialects") as there are teachers: for in one little way or another each teacher has his own independent idea as to what is best.

12. So far as drafting rooms themselves are concerned, it goes without saying that each has its own pet "dialect," or more than one; new draftsmen being generally expected to learn the practice of a "room" by observing existing drawings and doing likewise.

13. On all accounts it seems that there is a real need for a Universal Drawing Dictionary, and though any attempt to make the first one perfect and complete would fail, I believe it is possible to compile one that will be valuable at the outset, that will be improved and become much more valuable in time, that will from the first enable the school or college course better to prepare a man for actual work in the modern drafting room, and that many drafting rooms will be only too glad to adopt.

14. The third principle that I would like to see accepted is in the nature of a definition:

15. *Mechanical drawing is a language of lines, views, dimensions, signs and abbreviations, notes and explanatory matter, all for the positive conveying of exact information.*

16. The reader should particularly note the clause, "all for the positive conveying of exact information." A shop drawing is intended not as an expression of opinion to be *argued* about, but as a set of instructions to be *obeyed*. A drawing, therefore, should contain all necessary information and nothing else: and every statement, whether made by means of lines or words, or combinations of lines and words, should be absolutely free from ambiguity and as clear and easy to understand as the knowledge and common sense of the draftsman can make it.

17. In general, the proposed dictionary will cover the following features: Lines, letters and lettering, figures and dimensions, projection and projected views, sectioning and sectional views, methods of dimensioning, conventional signs and their meanings, finish designations and marks, conventional methods (the draftsman's idioms), some suggestions regarding designations and abbreviations of names, lists on drawings, a few example drawings, and suggestions regarding the compiling of standard data.

18. No attempt will be made to have the dictionary cover shop systems, because to be universal in character it must be good for any method of conducting business, just as the English dictionary is good for any method of handling a subject.

19. In this article a proposed alphabet of lines is presented. In presenting this and other features of the dictionary, I shall endeavor to state what the requirements are, to give all necessary definitions, and by argument to show that what is proposed is reasonable.

20. Here Fig. 1 names, illustrates, and defines the lines, while Fig. 2 is supplementary to the definitions given in Fig. 1 and is somewhat in the nature of an example drawing in which all the lines are used.

The requirements of the alphabet are:

1. That it shall be complete.

2. That the names of the lines shall be short and that they shall, as far as possible, indicate their use.

3. That the character of the lines shall be such that they can be readily distinguished one from another.

4. That the lines that are to be used the most shall show the greatest contrast, and be the easiest to draw.

21. The lines shown in Fig. 1 are designed as a "set" for pen work, to give satisfactory contrast, and are all drawn to the same scale; it is thus their *relative values* that are indicated, not a series of lines for mechanical copying. It is no more possible to have one weight and size of line suitable for all drawings than it is to have one kind and size of type suitable for all books. If this set of lines were reduced or enlarged by photography the same proportions and contrasts would be maintained. This indicates how the lines are to be used: No matter what the scale of a drawing there should be the same contrasts. In pencil work the contrasts will necessarily be less striking, but they can be maintained to a considerable degree when desirable.

22. THE OUTLINE.—There is really no room for argument about this line, except with regard to varying its thickness to give the effect of shading. Such shading lends some appearance of solidity to a view, but being expensive, it is very little used now in the drafting rooms of manufacturing concerns. However, the fact that it is used sometimes, as in government drafting rooms, where cost is not so closely figured, in patent office drawings, and for certain classes of illustrating, makes it best always to include it in a course of study. The ability to shade drawings is not only valuable in itself, but the study of it affords excellent practice in the use of drawing instruments.

23. THE HIDDEN LINE.—The illustration and definition do not require any special comment, this being the form already in general use.

24. THE CENTER LINE.—The unbroken, thin line is considered the best, not only because it is strictly in keeping with the meaning and purpose of the line, but because being the line from which principal dimensions are laid off, and in which centers are located, it *must* be accurate; and no other line can be drawn as accurately. The same line may be used for any imaginary line that is to answer the same general purpose as a center line; pitch lines for instance.

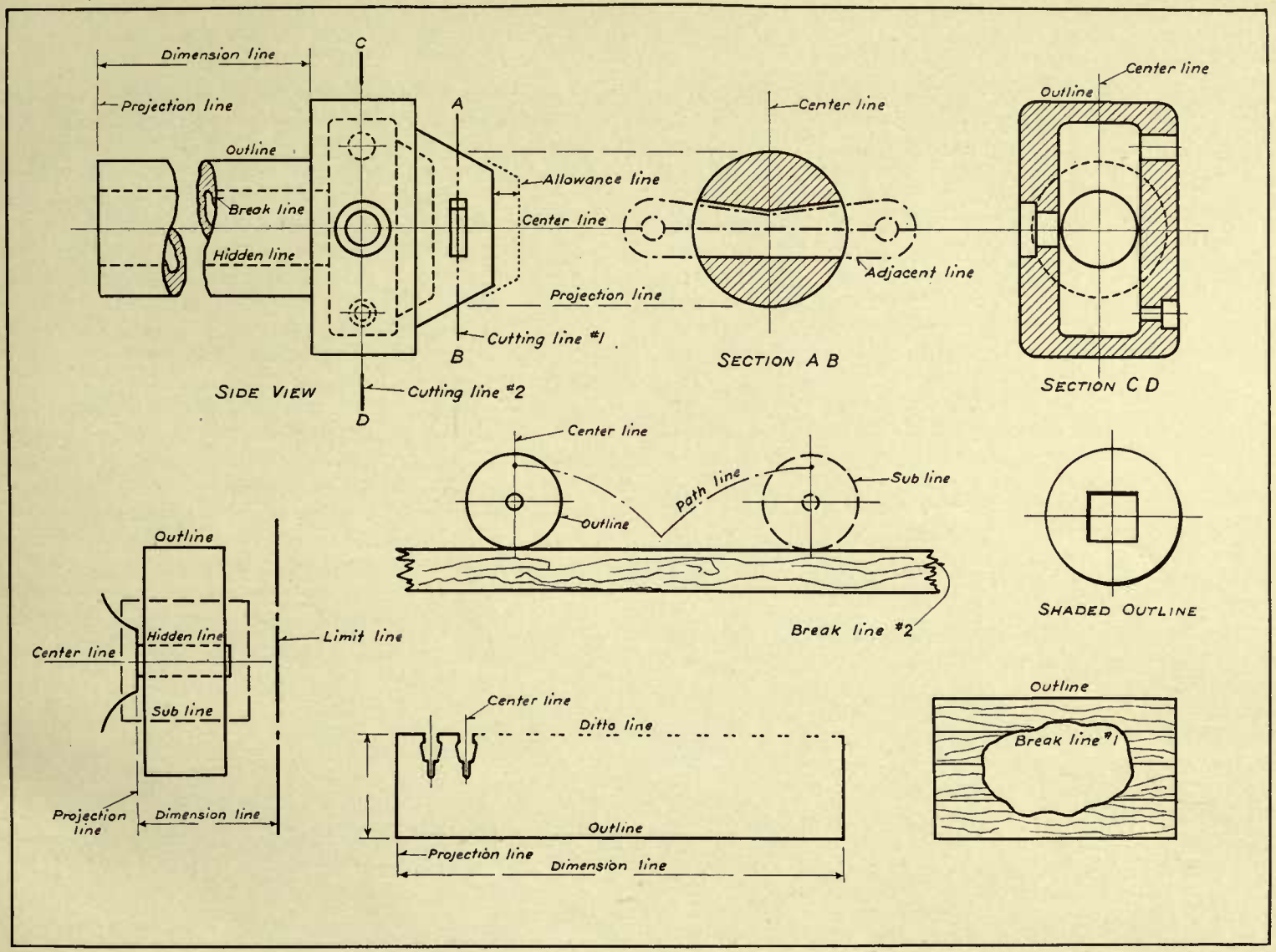

FIG. 2. INDICATING HOW THE TEN LINES OF THE ALPHABET ARE USED.

25. The Dimension and Projection Lines.—In mechanical drawings, unnecessary intersections of lines should be avoided; this helps to clearness, and is one reason for having the dimension and projection lines broken, so that they may cross one another without actually intersecting. A projection line should never quite touch a bounding line; bounding lines stand out much more clearly if they are not interfered with.

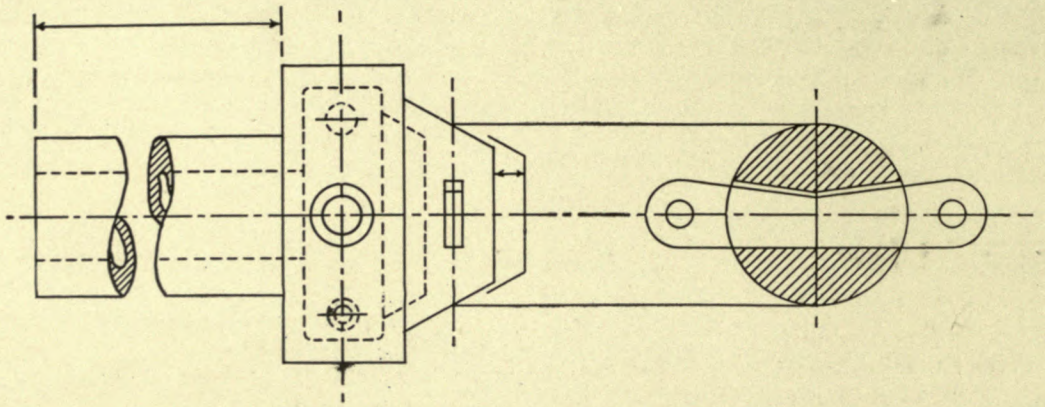

FIG. 3. SHOWING SIDE VIEW AND SECTION A B FROM FIG. 2 AS THEY APPEAR WHEN ONLY TWO LINES ARE USED.

26. The other lines do not call for any individual comment; they are all used in Fig. 2, where the lines of each view are named. In the Section A B and the side view belonging to it, ten of the fifteen lines are used. By way of contrast and with the idea of showing how very necessary it is to have an alphabet of lines, these same two views are repeated in Fig. 3, but with only two lines instead of the ten. The value of this alphabet of lines, like that of the dictionary itself, is more closely associated with the reading of drawings and the making of tracings than with the original work of the draftsman proper. An original pencil drawing bears somewhat the same relation to the tracing and blueprint made from it as an author's manuscript does to the printed book. In both cases the original is the work of one man and is not intended for the eyes of the public, while the result is to a large extent a mechanical product, and is for the reading of an unlimited number of men. And just as the duty of a publisher is to put the author's manuscript into such book form that the public may read with ease what the author has written, so it is the duty of the tracer to put the draftsman's work into such shape that others may easily read and understand it.

27. But although as directly affecting work done, the dictionary is

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more especially for the tracer and the "reader," the draftsman, too, must be minutely familiar with it, not only because a large part of his work is the reading of drawings, but because he must by notes or otherwise on his original drawings, however rough they may be, insure against misunderstandings on the part of the tracer.

28. The broad purpose of the dictionary, and of the alphabet of lines as part of it, is to make it easier for all concerned to read tracings and shop prints, and thus to save time every time a drawing is referred to. This is the immediate practical gain to be looked for from the general adoption of a drawing dictionary. There is also a gain of another and no less important kind: Mechanical drawing will cease to be something to "pick up," like bicycle riding, and will take its proper place as a universal language to be systematically studied; so that whether it is the draftsman that draws or the some one else that reads, there will be as little chance as possible for the misinterpretation or partial understanding of something that ought to be as plain as day.

CHAPTER II. LETTERS AND LETTERING.

29. The style of lettering used in the printing of this paragraph is particularly rich in letters that give shape and individuality to words. Take the word "sprightly," for instance: Seven of its nine letters either rise above or fall below the line, so that the complete word has a shape peculiar to itself. We recognize it at a glance, just as we do the face of some one we know; no more need to spell the word out letter by letter than to examine the face feature by feature; one look at the general shape is enough.

30. In reading this style of lettering we unconsciously recognize the words by their shape, and read the sentence phrase by phrase rather than word by word; so that the meaning is easily absorbed as the eye passes along the line.

31. THE STYLE OF LETTERING USED IN THIS PARAGRAPH—AND THIS IS A STYLE THAT UNFORTUNATELY HAS HAD A LONG RUN OF FAVOR IN DRAFTING ROOMS FOR NOTES ON DRAWINGS—ROBS THE WORDS OF ALL SPECIAL SHAPE OR PECULIAR OUTLINE, AND GIVES THEM A PAINFULLY MONOTONOUS SIMILARITY. IN READING THIS LETTERING WE UNCONSCIOUSLY SPELL THE WORDS OUT LETTER BY LETTER, AND READ THE SENTENCES WORD BY WORD INSTEAD OF PHRASE BY PHRASE. SUCH READING IS TIRESOME, BECAUSE THE MIND IS SO BUSY DECIPHERING WORDS AND PHRASES THAT BY THE TIME THE END OF A SENTENCE IS REACHED THE FULL MEANING OF IT IS RATHER MORE THAN LIKELY TO BE LOST.

32. All notes on drawings should be in a style of lettering that is easy to read; this is the first requirement. And the lettering should be easy to write, both well and uniformly.

33. In Fig. 4 two styles of letters and lettering are shown: One for all notes, and one for titles and headings. The lower-case letters have the advantage already described of giving individuality and shape to

CAPITAL LETTERS: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z &

LOWER CASE LETTERS: a b c d e f g h i j k l m n o p q r s t u v w x y z & abfgptyshd } 4 equal spaces
PROPORTIONS

THE OVAL in the lower case letters is shaped thus: ○, and inverted thus: ○: this oval or part of it is used in the following letters in the manner indicated:

a b c d e g h j m n p q r u

THE SLOPE for all letters is 3 in 8, thus: 3/8 Example 3/8

In A, V, W and Y the slope is obtained thus: A not A, V not V, W not W, Y not Y.

CAPITAL LETTERING: Examples: SECTION A B. PATTERN LIST. END VIEW.
This style of lettering is for titles and headings.

LOWER CASE LETTERING: Example: Make pattern to this line.
This style of lettering is for everything except titles and headings.

SIZES: Standard: 3/16" END VIEW 1/8" 1/16" Make pattern to this line. 1/12"

Small: 9/64" END VIEW 3/32" 3/32" Make pattern to this line. 1/16"

Large: 9/32" END VIEW 3/16" 3/16" Make pattern to this line. 1/8"

When there is not room for the standard use the small size.
The large size should be used only when it is advisable to give special prominence to a heading or note.

SPACING: STANDARD

7/32" In this example, letters, words and lines are correctly spaced.
The letters of a word should be reasonably close together.
Paragraphs should be indented as illustrated here.
5/32"

SMALL

In this example, letters, words and lines are correctly spaced.
The letters of a word should be reasonably close together.
Paragraphs should be indented as illustrated here.

LARGE

In this example letters, words and lines are correctly spaced.

FIG. 4. LETTERS AND LETTERING.

words; notes written in this style are very easy to read. The letters are so free from ornamental or superfluous features that they are equally easy to write; and the ideal simplicity of their construction leaves so little room for variety in the shaping that different men readily learn to write them alike. The capital letters, though unsuitable for notes, serve well for titles and headings.

34. The writer believes that for mechanical drawing, sloping lettering is better than vertical. An argument used by those who favor the vertical lettering is that there is only *one* vertical as against *any number* of slopes, and that it should therefore be easier to teach and get uniformity with the vertical lettering. But as a matter of fact, it is probably easier to get a sufficiently uniform slope than a sufficiently exact vertical, because a very slight deviation from the vertical is noticeable. In the average mechanical drawing there are so many truly vertical lines to compare with that the eye more readily detects a deviation from the vertical than from any given slope. Then again the sloping lettering stands out more clearly by contrast with the vertical and the horizontal lines of the drawing. However, in this matter, which is really one of *style* not in any way affecting the language proper, drafting rooms may be left to make their own choice. In this "dictionary" no attempt will be made to settle questions of style.

CHAPTER III. FIGURES AND DIMENSIONS.

35. In the average mechanical drawing the dimensions play the principal part, not only because they directly guide and control the work in the shop, but because many of them—what are generally termed the *working* or *finish* dimensions—have to play an active part during the entire life of the drawing.

36. By the term dimension as used here is meant the complete construction—the figure, the notation marks, the line and the arrowheads.

37. I would lay particular emphasis upon the fact that a working dimension is "alive" as long as the drawing is in use; so that if it is difficult to read, doubtful, or misleading, when the drawing is first made, it is again difficult to read, again doubtful, or again misleading every time it is referred to. Thus an indistinct arrow-head or a 3 that looks like an 8 is in the first place a possible source of error, and if allowed to remain may become a permanent source of trouble and expense.

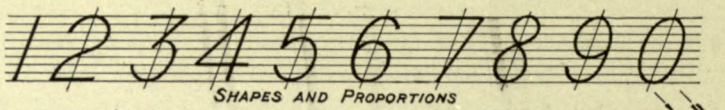
38. Every dimension should indicate with unmistakable clearness two things: First, the points or surfaces between which measurement is to be made; second, the distance to be measured. These are the chief requirements.

39. Fig. 5 deals with the several parts of a dimension, and shows a set of six standard constructions.

EXPLANATORY: By the term "dimension" is meant the figure, the notation marks, the line and the arrow-heads, as in the following example: ← $8\frac{3}{4}$" →

THE FIGURES: 1 2 3 4 5 6 7 8 9 0

THE SLOPE is 3 in 8, thus: 8 / 3



SHAPES AND PROPORTIONS

NOTATION MARKS: 3'-6" means a distance of 3 feet 6 inches. The marks are at a reverse angle of 45°

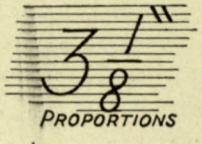
45°-30'-52" means an angle of 45 degrees 30 minutes 52 seconds.

The minute and second marks have the same slope as the figures.

DISTANCES: Examples: 3" 7'-6" 12'-0$\frac{1}{2}$" $\frac{5}{32}$" 3$\frac{1}{16}$" 3".1416 ".7854 5'-0".83

FRACTIONS: Numerator and denominator are separated by a horizontal fraction line.

DECIMALS: The notation mark is placed vertically above the decimal point.



PROPORTIONS

THE SIZE of the figures should be suited to the other parts of the dimension, and should be chosen with discretion. A suitable size for ordinary work is $\frac{3}{16}$", thus: ← $5\frac{1}{4}$" →

When immediately connected with lettering, the size should be the same as that of the capital letters, thus: Aug. 3, 1904 Fig. 28 Dwg. 23475

ARROW-HEADS: About 60°, made freehand. Size and weight to suit the other parts of the dimension.

CONSTRUCTIONS: The parts of a dimension can be arranged in six different ways, constituting what may be termed a set of standard dimensions.

1: ← $3\frac{1}{2}$" → ← $\frac{15}{16}$" → ← $38\frac{1}{2}$" →

2: → $3\frac{13}{16}$" ←

3: → ← $\frac{5}{16}$" → ← $2\frac{1}{2}$"

4: ‖→ ←‖ $\frac{13}{32}$" ‖→ ←‖ $3\frac{1}{4}$"

5: ‖— $4\frac{1}{8}$" —‖

6: ‖← $8\frac{1}{4}$" —‖

The purpose of these constructions is to make it impossible with ordinary care in reading to misunderstand the meaning.

Each construction is what may be called a "common sense" arrangement, and is subject to slight modifications as indicated in 1, 3 and 4.

In 5 the reversed arrow-heads mean to outside lines.

In 6 it is clear that the meaning is from inside line to outside line.

A dimension arrow-head should never be placed so that it is interfered with by any other line.

FIG. 5. FIGURES AND DIMENSIONS.

40. The Figures.—The figures in a drawing, like the letters, should be entirely free from ornamental or superfluous features, so that they may be both easy to read and easy to write. Those given have the required simplicity of construction without being in any way robbed of their individuality, and the shapes are such that it is practically impossible to mistake one figure for another.

41. What was said in paragraph 34 about the use of sloping lettering applies here to the sloping figures. If sloping lettering is adopted, sloping figures should also be used.

42. Notation Marks.—The peculiarity of the notation marks for the foot and inch is that they are sloped in the opposite direction to the figures. This is done to make it less possible for a mark to be confused with the figure 1, especially in connection with the numerator of a fraction. Incidentally this reversing of the marks gives additional character to a dimension.

43. Fractions.—The writer is of the opinion that the horizontal fraction line is better than the sloping one, not only because it is less liable to be scribbled, but because it makes a neater looking and more compact fraction.

44. Decimals.—The position of the notation mark is of importance. Placed as shown, it is a valuable check on the decimal point.

45. Constructions.—The clearness of a dimension depends largely upon the disposition of the arrow-heads and dimension lines with respect to the lines representing the points or surfaces of measurement. The constructions given will bear careful study. They are not by any means an insignificant part of the language of mechanical drawing.

CHAPTER IV. PROJECTION AND PROJECTED VIEWS.

46. In the English language it is not at all uncommon for a word to have more than one meaning. Sometimes the several meanings of the same word are due to accident and cannot be clearly traced to any positive source, but generally by stepping back through the forms a word has had in different languages it is possible to get at its earliest form and to discover its original meaning.

47. Many of the words we use have their "roots" among what are known as the dead languages, Latin and Greek; while the origin of others is even more remote. Ruskin, in one of his lectures, speaks of "words of true descent, of ancient blood," and would have us know the history of all such words. This is perhaps expecting too much, but there is wisdom in the idea, especially if we are reading to acquire definite knowledge. If under such circumstances we come across a word that has a vital bearing upon the subject, and we are not quite sure of its true meaning, it is wise to go to the dictionary and look up its derivation. We have examples here in the words "project" and "pro-

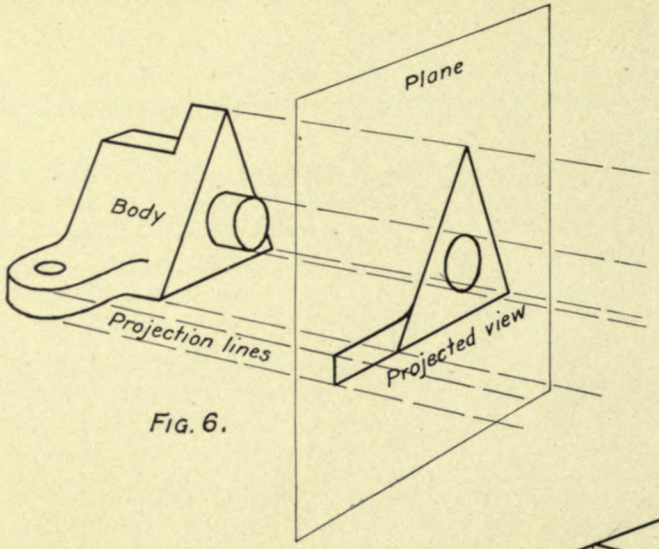


FIG. 6.

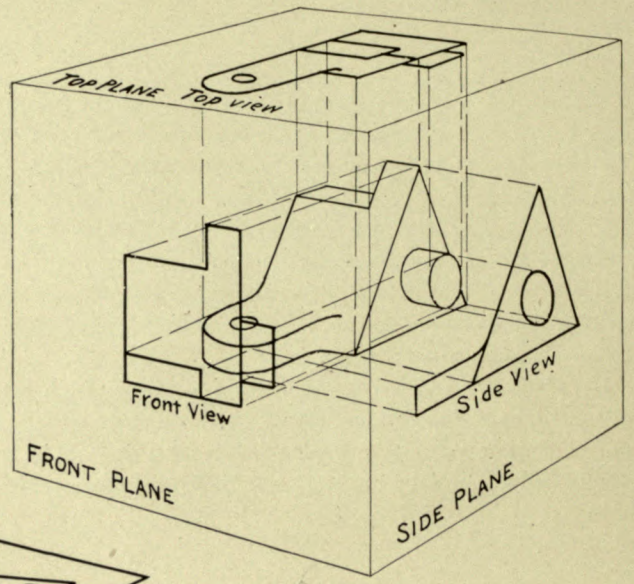


FIG. 7.

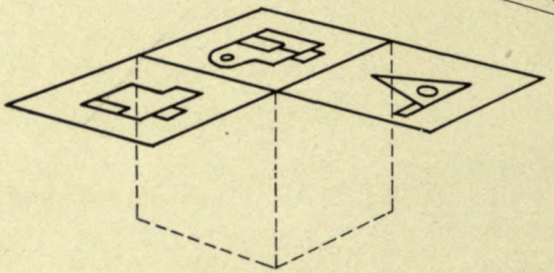


FIG. 9.

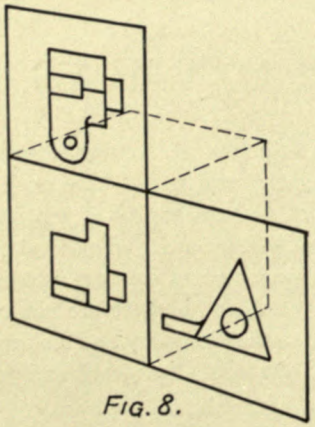


FIG. 8.

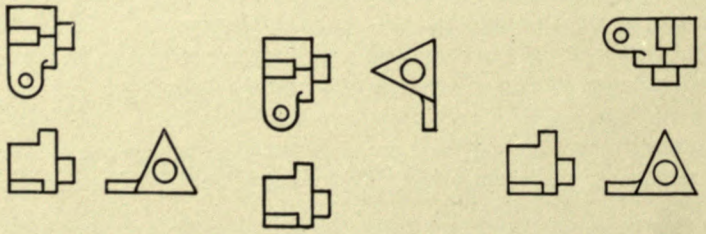


FIG. 11: *Showing three correct groupings of the same set of views.*

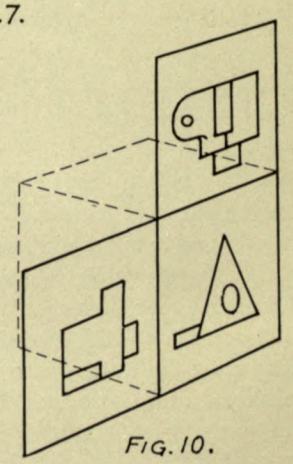


FIG. 10.

FIGS. 6 TO 11. SKETCHES ILLUSTRATING THE PRINCIPLES OF PROJECTION DRAWING.

jection," because they have several applied meanings and because it is of vital importance to understand their true significance in connection with mechanical drawing.

48. The Century Dictionary tells us that the verb "project" is derived from the Latin "projectare," out of the root words "jacere," to throw, and "pro," forth; and that its literal meaning is "to throw out or forth, to cast or shoot forward." The significance of the word as applied in mechanical drawing is "to throw forward in parallel rays or straight lines." And "projection" means "either the act or the result of projecting parallel rays from the surface of a body and of cutting these rays with a plane, so as to obtain on the plane a shape corresponding point for point with that of the body." (A "plane" is a perfectly flat surface; it has no thickness, and is therefore transparent.) In mechanical drawing the rays are called "projection lines."

49. It will thus be seen that the word "project" is not only of good and ancient lineage, but that as used in mechanical drawing its true significance is quite in keeping with its literal meaning.

50. In Fig. 6 a "body" is represented as projecting from its surface parallel rays, or "projection lines"; a "plane" is placed so as to cut these lines; and the intersections of the lines and the plane result in a "projection" corresponding in shape with that of the body.

51. In mechanical drawing a projection of this kind is called a "view," meaning that it is the "view" that would be obtained by an observer stationed on the same side of the body as the projection plane. This use of the word view is of course conventional.

52. In Fig. 7 the same body is represented as projecting rays in three directions; three planes are interposed, a top plane, a front plane, and a side plane; and three projections, or views, are obtained, which it would obviously be correct to call a top view, a front view, and a side view, respectively.

53. In Fig. 8 the three planes with their views have been brought into one surface. This brings the "top" view "above" the front view, and the "right"-side view to the "right" of the front view; a correct grouping. Two other groupings, equally correct, are shown in Figs. 9 and 10; and all three are mechanically reproduced in Fig. 11. It is evident that each grouping embodies the same principle of projection, and has precisely the same meaning; it is also evident that Fig. 7 is a full and complete interpretation of each group.

54. Thus in the language of mechanical drawing a solid body can be accurately and definitely represented by a group of projected views.

55. Unfortunately the method of projection employed in the above is only one of two that are in use at the present time. The other is known as "first-angle" projection, and this "dictionary" would be incomplete if it did not contain something akin to a definition of it. In geometry, when two planes intersect at right angles the angles are designated first, second, third and fourth, as numbered in Fig. 12. First angle projection places the body in angle No. 1 and projects a "top" view on to the plane "under" the body and a view of the "right" side on to the plane to the "left" of the body, and so on; that is, the projection lines, instead of being "thrown out from the surface," are "passed back through the body." In other words, the body is supposed to turn itself inside out.

56. The absurdity of this method, clearly demonstrated by contrast in Fig. 13, led to its being generally abandoned in this country, and it is to be hoped that the true method will eventually supersede it universally.

57. True projection is sometimes called "third angle" to distinguish it from "first angle." The name, however, is not only superfluous,

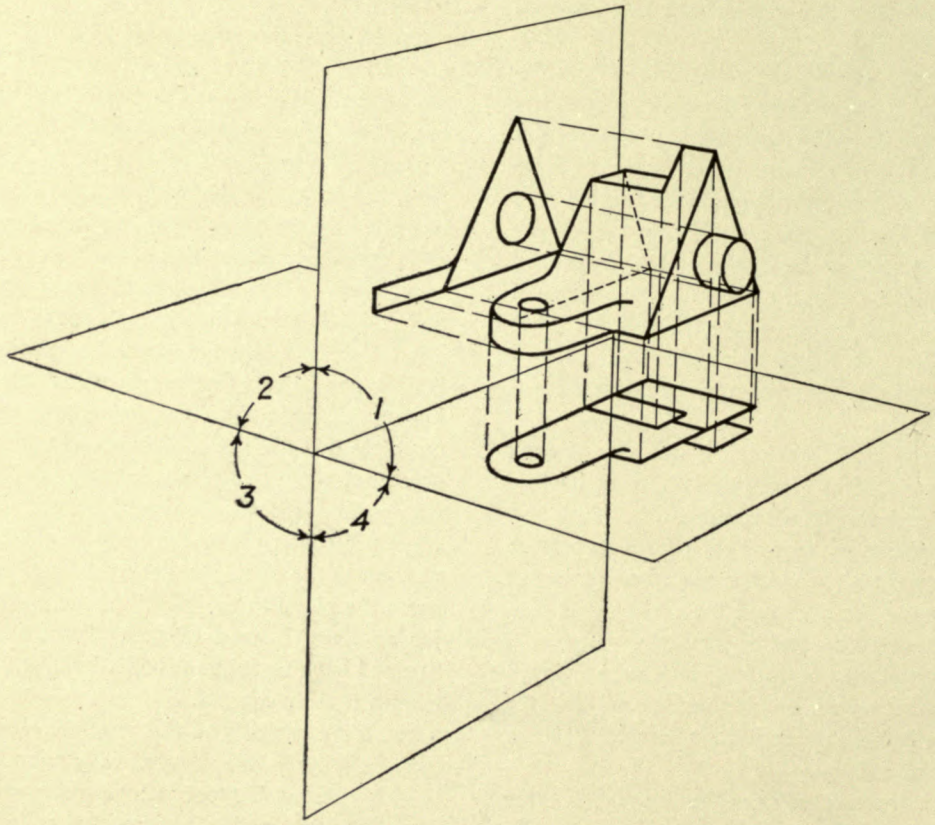


FIG. 12. SKETCH ILLUSTRATING "FIRST ANGLE" PROJECTION.

but can easily be misleading, because no matter which "angle" the body is supposedly placed in, or how many planes are employed, if true projection is used the views will always be orthodox.

58. In a mechanical drawing every view should be projected in the orthodox manner, and correct grouping should never be sacrificed, on the plea of convenience, to any mere "arrangement." If it is impossible because of the shape or limited size of a drawing to project a view into its proper place, a special view may be drawn; but such a view must not be placed as though it were projected from others, but must be distinctly separate and independent, and be suitably titled.

59. In mechanical drawing a group of views is a complete and comprehensive "sentence" (Paragraph 6, Chapter 1) and if one of the group is where it should not be, it amounts not merely to an error in spelling but to a misleading statement.

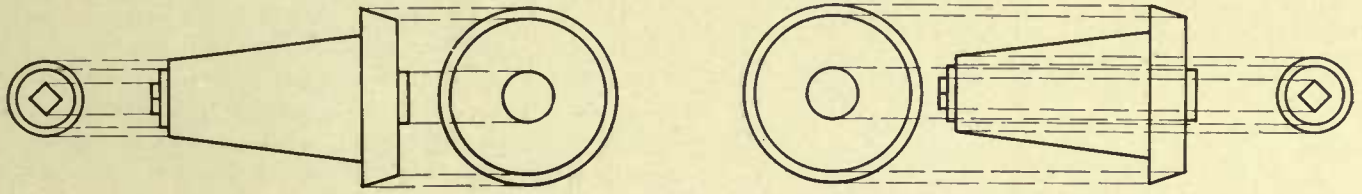


FIG. 13. FIRST ANGLE PROJECTION AND TRUE PROJECTION CONTRASTED.

CHAPTER V. SECTIONING AND SECTIONAL VIEWS.

60. SECTIONING.—This is a subject that has a rather interesting historical side. Time has made such sweeping changes in the work of the draftsman—due largely to the invention of blue printing and other copying processes—that we have come almost to forget what a drawing of a generation ago was like, and to entirely lose sight of the influence that some of the old-fashioned methods have had upon the drawing of to-day.

61. Before the introduction of blue printing, the "original" drawing was used by all concerned, and was quite an elaborate and expensive affair compared with the shop print of to-day. In the first place it was

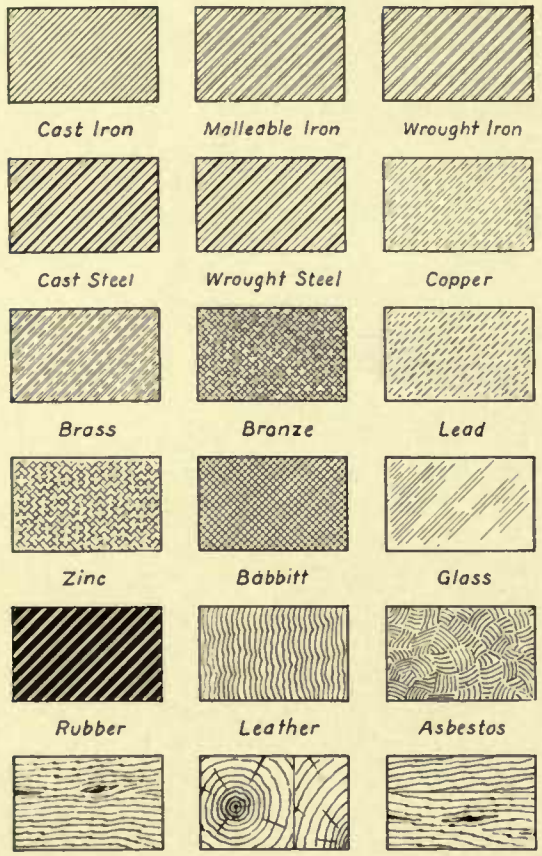


FIG. 14. STANDARD SECTION LINING FOR DIFFERENT MATERIALS.
(Reproduced from Reinhardt's "Technic of Mechanical Drafting.")

made on the best and toughest of paper—it *had* to be to stand the wear and tear; then it was inked in with genuine "India" ink rubbed down from the stick; and if it was a drawing of a standard machine it was shaded with the brush and symbolically colored according to the materials of construction. Then before being put into service it was carefully mounted on a suitable board or cloth and given a coat of shellac to preserve it and make it washable. Such was the work of some of the "old-school" draftsmen of twenty-five or thirty years ago—very different from the "product" of the modern drafting room.

62. In the use of the brush, for shading and for the coloring of surfaces in section, the old-time practice had a decided influence on the line sectionings that prevail to-day. When colors were used, cast iron in section was represented by an even wash of gray, wrought iron by Prussian blue, steel by a thin wash of crimson lake; while brass was tinted gamboge yellow, and wood was imitated in both color and graining as closely as the draftsman knew how.

63. With the general adoption of tracings and blue prints, shading with the brush died a natural death, giving way first to line shading, later to shaded outlines, and finally to no shading at all; and color sectioning was superseded by line sectioning as used to-day.

64. Now it is necessary to bear in mind that when the custom was to represent materials by symbolical colors, there were comparatively few constructive materials in use, compared, that is, with the far greater number and variety employed at the present time. To a very large extent cast iron was then simply cast iron, brass was brass, and steel—what little there was of it—was not used in so many grades as to call for a special set of symbols. Thus a few colors were able to represent the materials in common use with sufficient precision. So also when the advent of the blue print called for "lines" in place of "colors," it

was not necessary to have any great number of symbolical "sectionings." Cast iron was satisfactorily represented by evenly spaced parallel lines; wrought iron by alternate thick and thin ones; steel by lines in pairs; brass by alternate full and broken lines, and so on. But in later years the additional number of materials employed has called for some ingenuity in devising sufficiently distinctive sectionings; the writer has seen authorized varieties that were not only quite difficult to produce, but painfully uncomfortable to look at.

65. Fig. 14 shows a set of sectionings such as are used to-day in many drafting rooms. It is a good set* and would be fairly satisfactory were it not that materials are now made in so many different grades, and there are so many alloys, and so many new materials—or old ones modified to suit special kinds of service—that it is no longer possible to represent materials precisely by symbolical sectionings.

66. Again, many of the big manufacturing concerns now have their own "official specifications" for the materials they purchase or produce, such specifications covering both the chemical and the physical requirements. On drawings, therefore, it is becoming customary to call for a material either by full descriptive name or by general name and specification number. Thus a bearing metal may be specified as "No. 6 Alloy"; a steel may be "Axle Steel, Specification No. 6140"; a shaft may be called for as "Open-hearth steel, oil tempered and annealed"; an aluminum bronze may be known as "No. 15 Bronze"; and so on.

67. Symbolical sectioning then is no longer sufficient in itself as an indication of material.

* For this set the author is indebted to "Reinhardt's Technic of Mechanical Drafting," in which excellent work the reader may find a comprehensive treatment of some sixty-five very effective individual sectionings.

68. These considerations induced the writer some five years ago to suggest that sectionings be used to indicate not individual materials but classes of material.

69. Fig. 15 gives a suggested classification and a set of suitable sectionings. Briefly the classification is well expressed by the meanings of the sectionings themselves; thus:

No. 1 means "Metal."
No. 2 " "Poured into place hot."
No. 3 " "Poured into place cold."
No. 4 " "Fibrous or flexible."
No. 5 " "Flexible insulation."
No. 6 " "Wood."
No. 7 " "Stone class."
No. 8 " "Liquid."
No. 9 " "Special."

70. For the principle involved in this classification three distinct advantages are claimed:

First: There are so few sectionings required that it is not necessary to use any that are at all difficult to produce.

Second: Each sectioning has a constant and definite meaning.

Third: A change of material after a drawing has been made does not necessitate the erasing of a sectioning, unless the new material belongs to a different class, which will very rarely be the case.

71. What may almost be considered as a fourth advantage is illustrated in Fig. 16, where by suitably varying the thickness and spacing of the "metal" sectioning lines the different surfaces show good contrast. This contrast or "color effect" is fully equal to anything that can be

The sections given here are not for individual materials, but are for indicating the broad classes of the materials used in machine construction.

The thickness and spacing of the lines should be varied to suit the size of the surface and the character of the drawing.

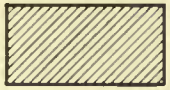
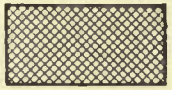
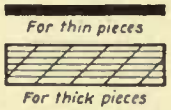
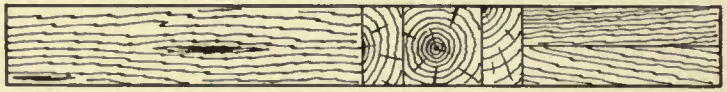
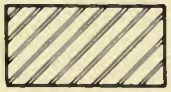
1: METAL:		For all metals except when they belong to Class 2.
2: POURED INTO PLACE HOT:		For materials that are to be melted and poured into place hot, and that set solid when cool. Babbitt metal and similar alloys, lead, solder, sulphur, wax, paraffin and pitch are examples. Materials that are to be softened by heat and squeezed into place should also have this sectioning.
3: POURED INTO PLACE COLD:		This will generally mean some kind of cement, as Portland and other hydraulic cements, plaster of Paris, concrete, mortar. It should also be used for pastey or plastic materials, as tallow, putty, etc. when squeezed into place without being heated.
4: FIBROUS OR FLEXIBLE:		For such materials as leather, leatheroid, rawhide, fibre, asbestos, felt, rubber, gutta-percho, ivory, bone, etc.
5: FLEXIBLE INSULATION:		For use especially in connection with electrical apparatus. Materials that would mechanically belong to the preceding class should have this sectioning when they are used for insulating purposes. Mica, paper, cloth, fibre, fullerboard and rubber are examples.
6: WOOD:		It is often desirable to imitate the grain of wood whether in section or not.
7: STONE CLASS:		This sectioning should be used for materials that belong to the same general class as stone. Marble, slate, soapstone, brick, terra-cotta, porcelain and glass are examples.
8: LIQUID:		For all liquids that do not set solid at ordinary temperatures, as oil, water, alcohol, glycerine, turpentine, etc..
9: SPECIAL:		For materials that are entirely special, or that do not belong to one of the above classes.

FIG. 15. STANDARD SECTIONING FOR CLASSES OF MATERIALS.

obtained by individual sectionings and is produced with decidedly less trouble.

72. It is at once apparent that the sectioning for a given individual material will not always be the same, but may change with its function or with the method of preparing it. Thus, a separately finished piece of babbitt metal will have sectioning No. 1; the same material poured into place hot will have No. 2. So also with a piece of fiber: Used as insulation (whatever other function it may fill) it will have sectioning No. 5; used mechanically—and not as insulation—it will have No. 4 sectioning. In each case the sectioning points definitely to the class of material, not to the material itself.

73. If, as is sometimes the case, it is desirable to specify the individual material in immediate connection with the surface in section, it is easily done by writing the name of the material on the face of the section, or near it—as in Fig. 16.

74. Sectional Views.—The grouping of sectional views is governed by the laws of projection as stated in Chapter IV, and needs no special comment.

75. When there is a set of sections on parallel planes, the views should be arranged in the reverse order of the planes; and the cutting lines should be so lettered that the views will fall in alphabetical order reading away from the view from which they were projected.

76. In the lettering of cutting lines the planes should be considered as cutting either downward or from left to right and the lines lettered accordingly. Vertical cutting lines will then be lettered AB, CD, etc., reading downwards; horizontal ones, AB, CD, etc., reading from left to right; and if inclined, it will generally be easy to decide whether the line should be considered as inclined to the vertical or to the horizontal, and this will determine how the lettering should read.

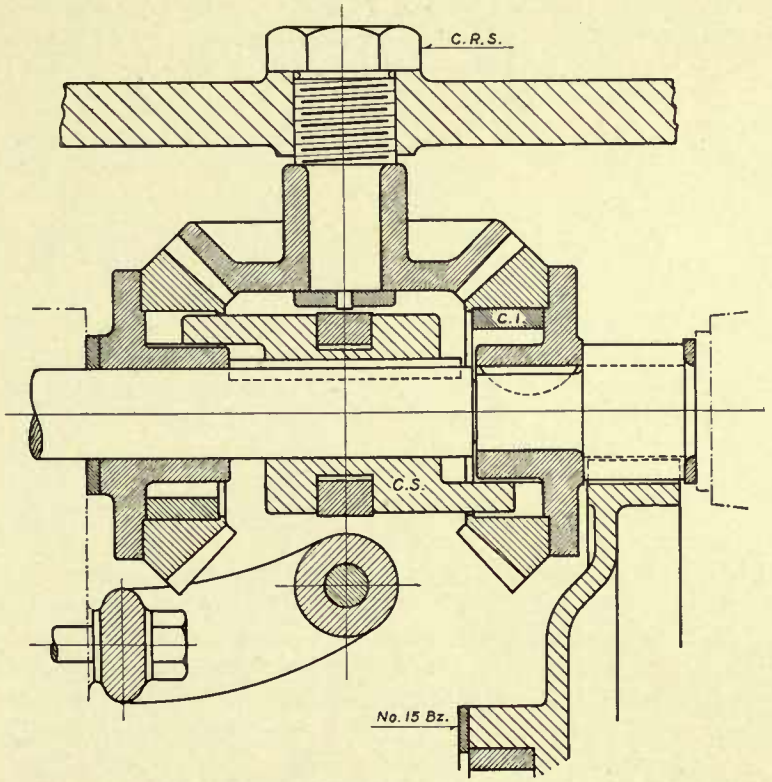


FIG. 16. ILLUSTRATION OF EFFECT OF VARYING WIDTHS OF SECTION LINING FOR DIFFERENT MATERIALS OF THE SAME CLASS.

77. Broken Sections.—It is sometimes desirable to make a single sectional view answer the purpose of two or more, by using a bent, or "broken" cutting line instead of a true cutting plane. This kind of section is best indicated by the use of an additional letter at each bend or break in the cutting line and should always be lettered in this manner, as ABC, instead of simply AB; this will distinguish it at a glance from a true section, and will make the drawing just so much easier to read.

CHAPTER VI. FINISHES AND THE FINISH MARK.

78. In every-day English the word *finish* means "to complete." In workshops the same word has several other meanings; one of them—common in machine shops—is "to shape to dimensions with a cutting tool." It is perhaps unfortunate that custom has permitted the word to be used in this special sense, but it cannot be helped; and it is not likely that anything would be gained by an attempt to introduce a new word as a universal substitute, especially as *Face*, *Dress*, and *Shape* are already used in some shops to mean the same thing. It is probably best to accept conditions as they are, and agree that the special meaning of the word shall hold.

79. Broadly speaking, any process by which a surface is completed is a finishing process, the result of which is a finished surface—or simply a "finish." It is part of the business of the draftsman to say what the nature of a finish shall be; it is not necessarily his business to state by what process a finish shall be obtained, but it is *essential* that the drawing shall indicate the finish itself—the *result*.

80. In this there is a principle involved: *A drawing should be made right to stay right;* which means, among other things, that it should as far as possible allow for changes in shop methods, so long as the results obtained are the same. There is an application of this principle in Chapter V, paragraph 70: "A change of material after a drawing has been made does not necessitate the erasing of a sectioning"; in other words, the sectioning is made right to stay right.

81. In the matter of finishes it is distinctly poor practice for a drawing to say how a result shall be obtained; for example: If it says "plane," and the shop "mills," the drawing is wrong. It is not possible to say exactly when and when not to specify a finishing process; sometimes it is necessary, but on principle it should be avoided, because unless it is agreed that a change of process shall be immediately followed by a change in every drawing that calls for the superseded process—which would be an unbearable hardship—drawings are liable at any time to become ineffective and misleading.

82. The finishes that it is necessary to specify in mechanical drawings can be divided into two general classes: (1) Tool finishes, produced by cutting or abrading. (2) Coat finishes, obtained by coating with some preservative.

83. The following are a number of Tool Finishes with their definitions:

FINISH.—Shape to dimensions with a cutting tool. This calls for measured adherence to dimensions (either within limits as stated on the drawing, or as considered suitable by the shop); the surface to be such as good shop practice requires, but not to have anything done upon it for mere appearance.

SPOT FINISH.—Finish a circular spot. This calls for measured adherence to dimensions, and can be done with a counterbore or similar tool.

SPOT FACE.—Face a circular spot. This does not call for measured adherence to dimensions; otherwise it is the same as spot finish.

TRIM.—Shape by any convenient means; as by chipping, filing, sawing, grinding, etc. This does not call for measured adherence to dimensions.

POLISH.—Make the surface smooth and glossy. Except when used in conjunction with "Finish," this does not call for measured adherence to dimensions nor for a perfectly true surface. It can be produced by such means as grinding and buffing.

GRAIN.—Give the material the appearance of having a straight grain; as by drawfiling or rubbing with emery cloth.

MATT.—Make the surface artistically rough. This can be done by direct hand work or, in the case of a casting, by covering the face of the pattern with pebble-surface paper.

84. These finishes with their definitions are intended to relieve the draftsman of responsibility and to place it on the shop where it rightly belongs. An example will show what this means: In a certain establishment, during a number of years, several hundred drawings were made specifying that certain holes should be "drilled." To-day, by means of modern tools these holes are accurately punched; and now the drawings are wrong to stay wrong, for they will never be corrected; it would cost too much.

85. It is generally no affair of the draftsman's—or at least not necessary for the drawing to state—whether the shop will plane, mill, shape, bore, broach, drill, punch, chip, file, saw, grind, scrape, ream, or how a result will be obtained. The drawing must, however, indicate required results; this is what the finishes given above are intended to do, without limiting the shop to any specified processes. The judgment of the

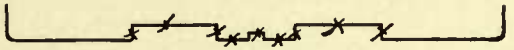


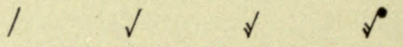
FIG. 17.

draftsman should tell him when it is necessary or wise to specify an actual process. In some cases the name of the finish is also the name of the process; "Knurl" is an example.

86. COAT FINISHES.—A great number and variety of finishes belong to this class; as paint, lacquer, varnish, shellac, French polish, Japan, electroplate, oxidize, boil in oil, etc. It is proper to designate these finishes by full descriptive name or by some well-understood abbreviation of it.

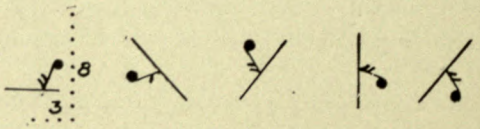
87. THE FINISH MARK.—In drafting rooms it is common practice to mark with an "f" the bounding lines of surfaces that are to be "finished." Unfortunately this "f," as a finish mark, easily degenerates into an untidy scrawl; it is too readily scribbled, and when applied as in Fig. 17—which is an example from an existing working drawing—it is altogether unsatisfactory.

THE FINISH MARK: √ Drawn freehand. Consists of a thin, straight pointer line, with two medium-weight barbs on one side of the line and a circular head on the other side.
SIZE: The standard is $\frac{3}{16}$" √ but this should be varied to suit the character of the drawing and the space available.
MANNER OF CONSTRUCTING: First draw the pointer line; add the barbs; finish with the head.



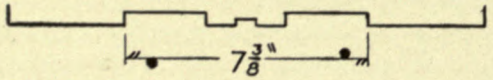
CONSTRUCTION IN FOUR STEPS

ORDINARY APPLICATION: Apply to the bounding line of the surface at an angle of 3 in 8, as in the following examples: The barb should always be in the obtuse angle formed by the pointer line and the line of surface, never thus: √



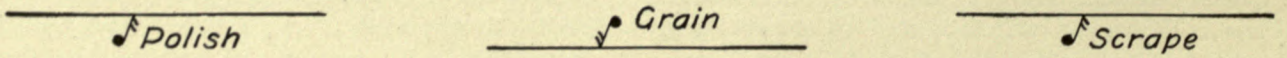
EXAMPLES OF APPLICATION

SPECIAL APPLICATION: When a surface is of such a shape as to naturally require several finish marks inconveniently close together, indicate the extent of the finish by using two marks as dimension arrow-heads, thus:



This means that the entire surface between the projection lines is to be finished. Compare this with Fig. 17.

CONJUNCTIONS: Sometimes it is necessary to specify a double finish, as "Finish and Polish." The mark can then be used in conjunction, thus:



It is often advisable to specify a finish by means of a note, as Finish all over: Trim flush with edge of flange: Finish and Polish from A to B: Polish exposed surfaces: Grain parallel to edge C D.

FIG. 18. THE FINISH MARK.

88. The finish mark presented in Fig. 18 was the outcome, some five years ago, of an effort to find something better than the "f." It possesses the advantage of pointing to the line instead of cutting it; it has a distinct individuality and is very visible, it is easy to draw but difficult to scribble, and the special application of it for broken surfaces is decidedly valuable.

CHAPTER VII. DIMENSIONING.

89. In attempting to lay down the general principles upon which a study of mechanical drawing should depend, I said, in Chapter I., that mechanical drawing is a language.

90. Now, the writing of a language may be for a variety of purposes. The English language, for example, is used in an almost endless variety of ways, to obtain an almost endless variety of results; from the speaking of a simple sentence, resulting in the making known to another person of a simple fact, to the written expression of a scientific theory, based upon a multitude of facts, and resulting in the printed reference book for the benefit of many people.

91. For the guidance of those who use our language, comprehensive dictionaries and encyclopedias have been compiled, and a recognized science called grammar deduced; so that no matter what the result of writing the language may be, whether it be a reference book or a magazine story, an engineering specification or an advertising pamphlet, a railroad ticket or a theater poster, the same alphabet and words are employed, with the same methods of sentence construction. But this similarity of language does not prevent us from easily distinguishing a railroad ticket from a theater poster, or a reference book from a magazine story; because each is built on its own lines for its own purposes. And it would be quite useless to try to formulate special rules for the preparation of one that would be of any practical assistance in the preparation of any other.

92. It is much the same with this language of lines, for there are many kinds of mechanical drawings; and before any attempt can be made to deal intelligently with the subject of dimensioning it will be necessary to arrive at a concise and comprehensive definition of the particular kind of mechanical drawing that this dictionary is intended to govern.

93. If the sole purpose of a drawing be to discover some unknown dimension, it is generally called a "layout." With the discovery of the dimension such a drawing has played its part; its work is finished. Similarly, if its purpose be to determine the contour of a cam, it serves its purpose and may be destroyed. Again a mechanical drawing may be in the nature of a thesis—an essay in lines, as it were; or it may be intended solely for descriptive or illustrative purposes.

94. So far as the language itself is concerned certain grammatical rules, as those governing projection and the meaning of the dimension line, must always hold; but there are many rules, among which are

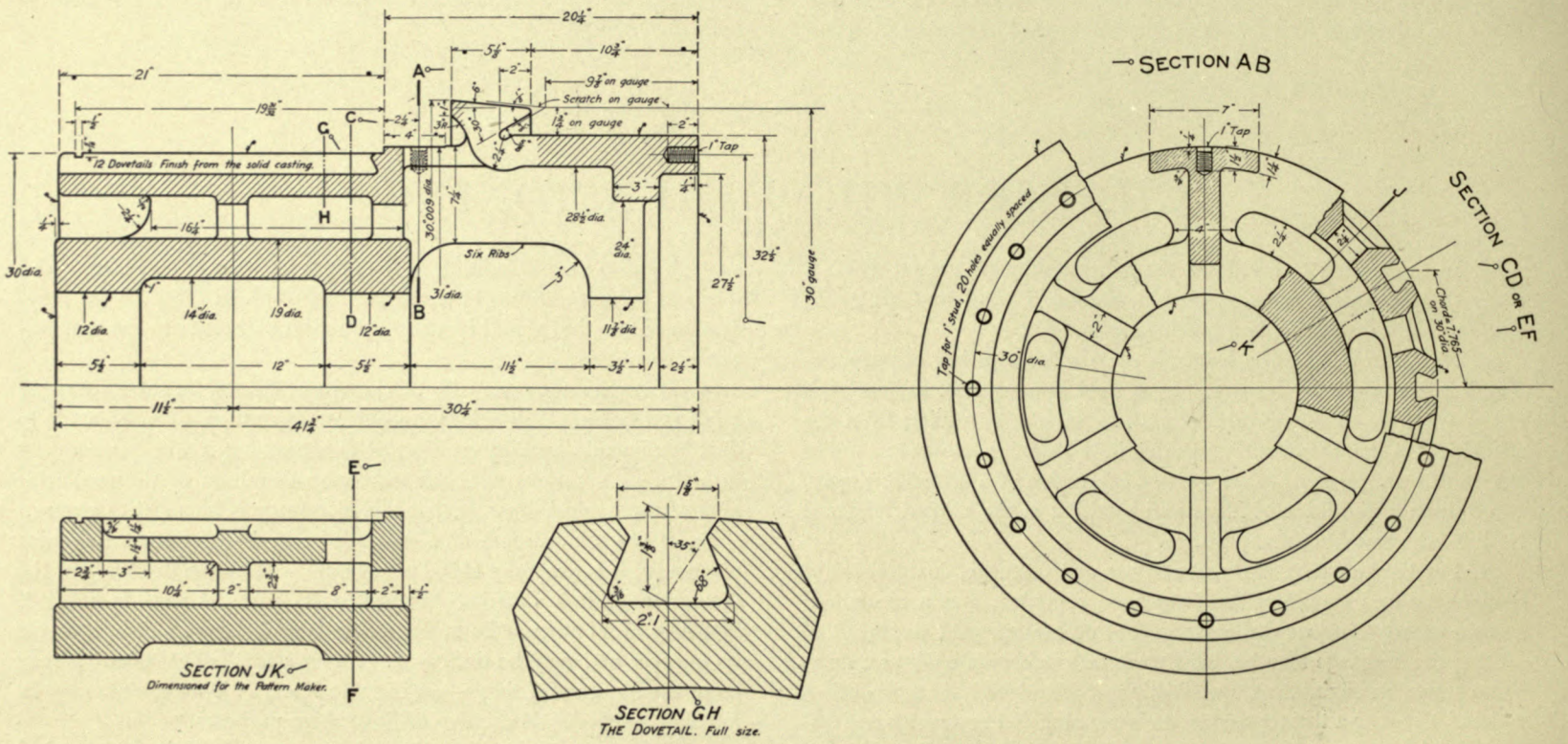


FIG. 19. CAST-IRON ARMATURE SPIDER.

those that govern dimensioning, whose application will depend to a large extent upon the kind of drawing required and the uses to which it will be put.

95. *When a mechanical drawing illustrates the shape and construction of something that is to be made, and specifies the required product—as by giving dimensions, material, finish, and quantity required—it is in effect an illustrated specification.* This is the particular kind of drawing that we are interested in here and that this dictionary is intended to govern —the "illustrated specification," for the use of shop, office, and drafting room, to be referred to again and again by those concerned in the manufacture, sale, or design of the specified product.

96. In relation to such a drawing, the definition given in Chapter I.— that "mechanical drawing is a language of lines, views, dimensions, signs and abbreviations, notes and explanatory matter, all for the positive conveying of exact information"—has an interesting significance, for we may at once divide the drawing into three simple elements— illustration, dimensions, and written matter.

97. In composing such a drawing, the problem is how to distribute these elements so that each may play its part to the best advantage.

98. Taking first the illustration—the projected view or views—the primary purpose is, of course, to show a required shape or design; but this is not always the most valuable purpose *finally*. In every drawing the illustration is made to serve as a "vehicle" for the dimensions, and very often it is eventually of more value in this capacity than as a "shape." Take, for example, the illustration of the cast-iron armature spider in Fig. 19. After the pattern has been made, the drawing is referred to in the shop, not to discover the shape of the casting, because the pattern has fixed that and the casting is *there*, but for the dimensions and written matter.

99. It behooves the draftsman occasionally to remind himself of the fact that the man in the shop has the drawing in one hand and the piece in the other, and is looking to the drawing for a dimension that he *needs* and has a right to *expect*; that if it is not given he has a right to complain, and that the illustration—as a "vehicle"—should carry the dimension *naturally*, where it can be easily found and easily read, and, if possible, where the man in the shop will naturally look for it.

100. *Dimensioning may therefore be defined as the art of determining what dimensions are required, and of applying them correctly to the lines and views of a drawing.*

101. Required Dimensions.—It often happens that the dimensions used by the draftsman as he develops a design would not be convenient as working dimensions for the shop. In other words, the dimensions required by the shop are not always the same as those used in the drafting room. The shop requirements generally depend upon the way in which the work will be done—the manner in which measurements will be made and the order in which surfaces will be finished. Fig. 20 shows two dimensionings of a part of the casting illustrated in Fig. 19; at *a* the dimensions are numbered in the order in which the surfaces will be finished. Dimensioned as at *b*, the shop would have to add *A*, *B*, and *C* together to get No. 1, *B* and *C* to get No. 2, and would not need *A* at all.

102. This leads to a statement of the first principle to be observed— *dimensions should be so given that the shop will not have to add or subtract in order to discover required distances.* This is only another way of saying "give the dimensions that the shop requires," except that it points clearly to the necessity of not being satisfied unless the dimensions are *individually* what the shop will want to *use*. Such dimensioning calls for a greater knowledge of shop methods than the average

draftsman of to-day possesses; also for more thought than he usually gives to the subject; but it would go a long way toward removing that prejudice between drafting room and shop which we have come to look upon as almost a necessary evil.

103. So far we have spoken of the "shop" as though it were a unit; in reality the engineering shop consists of several more or less independent workshops, as pattern shop, foundry, machine shop, etc. Now, it is often necessary to bear in mind that the dimensions required by the different workshops may differ widely from one another, both in character and value. Thus, when the drawing represents a casting, as does Fig. 19, some of the dimensions will be especially for the pattern shop, others for the machine shop, some for both. It is always worth while to consider the shop requirements and the nature of the work to be done.

104. As a rule, the working or finish dimensions—those required by the machine shop—have the greatest value, and will rank first in importance, because they directly guide and control work done on raw material and have to play an active part during the entire life of the drawing (see Paragraph 35, Chapter III.). The dimensions for the pattern shop are generally of least "final value," not because they are any less important *originally*, but because, after the pattern has once been made, they are seldom used. In some drafting rooms special drawings are made for the pattern maker, carrying his dimensions only, the "working" drawings being thus relieved of their burden.

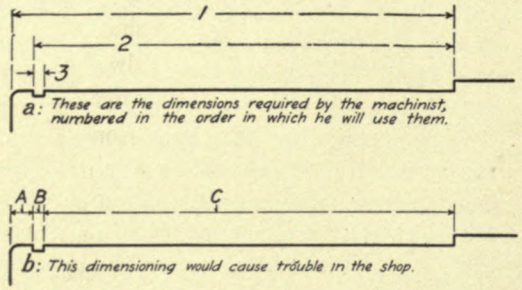


FIG. 20.

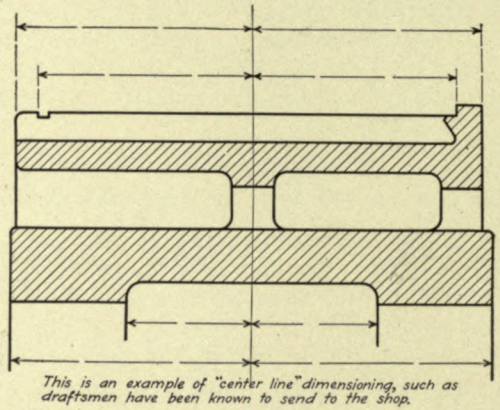


FIG. 21.

FIGS. 20 AND 21. EXAMPLES OF METHODS OF DIMENSIONING.

(Both are based on a part of the casting shown in Fig. 19.)

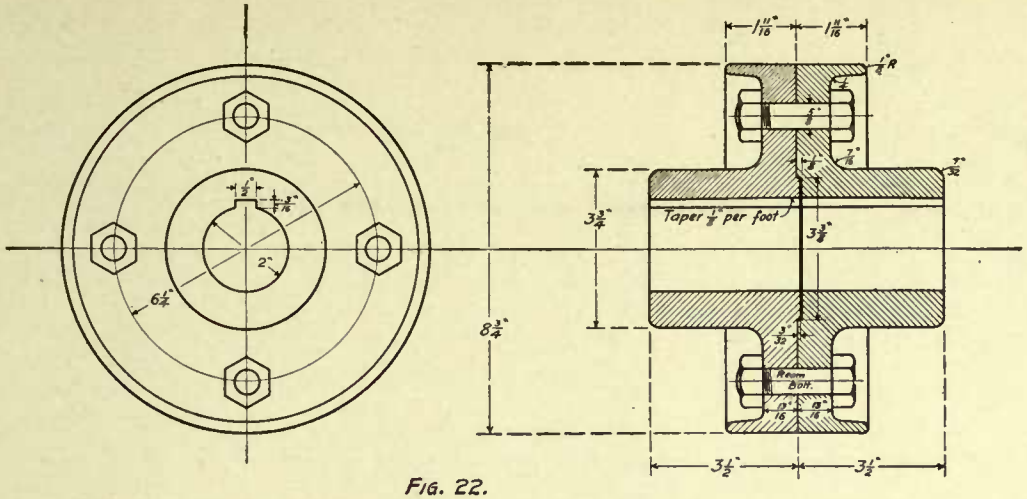


FIG. 22.

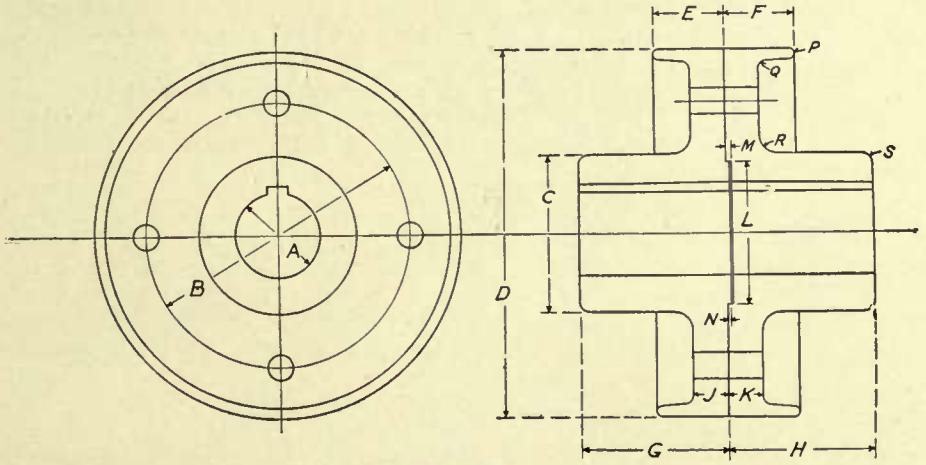


FIG. 23.

FIGS. 22 AND 23. GOOD DIMENSIONING FOR FLANGE COUPLING, WITH KEY TO SAME.

Key to the Dimensioning in Fig. 22 (see Fig. 23).

The following is intended to show that there is often a reason why a dimension should be applied in one place rather than another. The reasons are given, not because there is anything final or definite about them, but to suggest a line of thought, and to show that there is such a thing as intelligent dimensioning.

A: The bore will be measured from the end.

B: This center line circle will be laid out on the end.

C and D: The dimensions are applied as the diameters will be calipered.

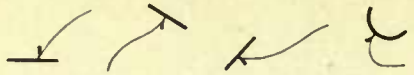
E, F, G and H: These external dimensions are placed outside the view.

J and K: These internal dimensions are placed inside the view.

L: This diameter is placed as it will be calipered, and to the right because the part referred to points in that direction.

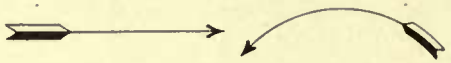
M and N: Each of these dimensions is placed on the half of the coupling to which it belongs.

P, Q, R and S. Grouping the radius dimensions in this manner is better than scattering them, and there is clear room for them on this side of the view.

THE POINTER:  Consisting of thin pointer line of suitable shape, with a single-barb head. The barb should always be placed on the more open side of the pointer line, thus ↙ never ↙

In general the Pointer is for definitely connecting a note or dimension with some part of the drawing. The barb should always touch the part referred to.

THE INDICATOR: Consisting of a short, medium-weight direction line with a small circle at one end. This sign is shown to advantage in Fig. 19 where it serves as an indicator between the sectional views and their respective cutting lines. The "indicator" also forms a part of the "substitute for a repeat dimension"; see Fig. 31.

THE ARROW:  Consisting of thin direction line, shaded feather, and a double-barb head.

In general the arrow is for indicating direction of motion or force.

FIG. 24. SIGNS OF DIRECTION.

DIAMETERS and RADII: The following example dimensionings of diameters and radii are intended to show that no matter what the surroundings of a circle or arc may be, it is generally possible so to apply the dimension that the drawing will be easy to read and good to look at.

In example A it is made clear that the $72\frac{3}{8}$" is a diameter, and in B, that the $13\frac{1}{2}$" is a radius. The abbreviations "dia." for diameter, and "R" for radius should be used in this way whenever there could otherwise be a doubt as to the meaning of a dimension; but when the meaning is evident the dimension alone is sufficient.

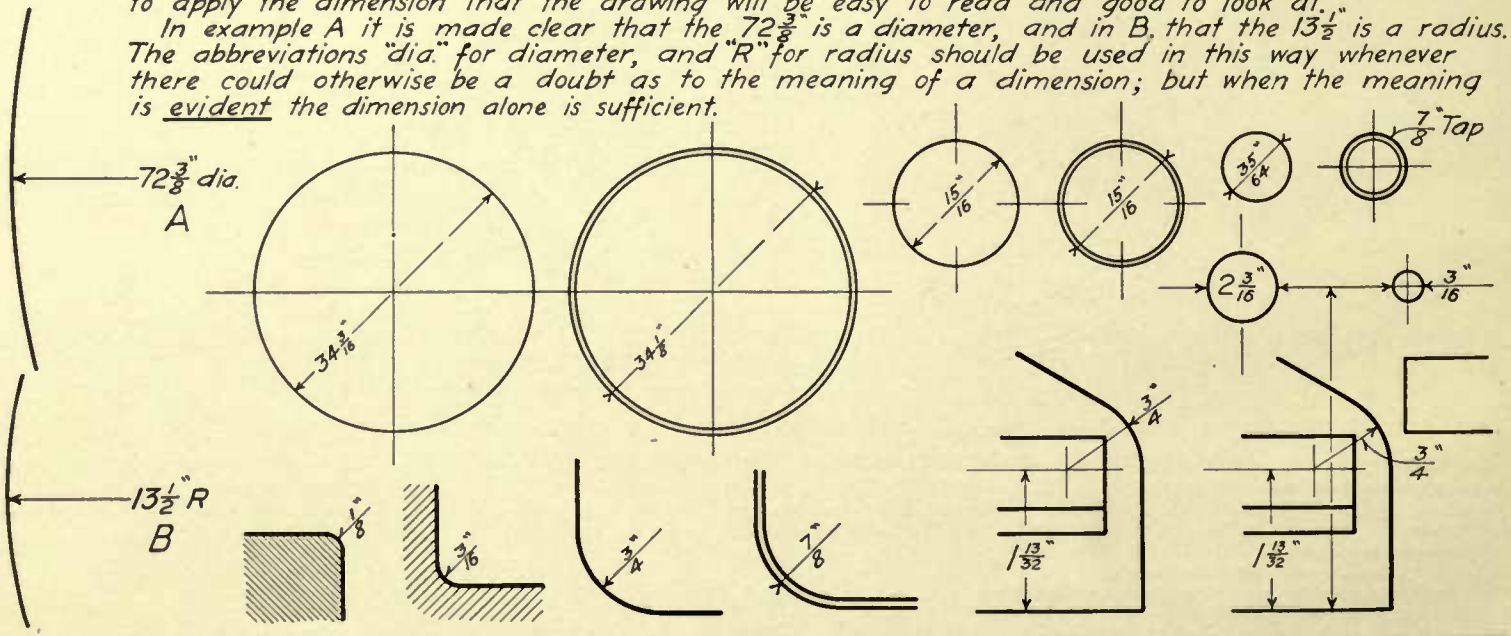


FIG. 25. THE APPLICATION OF DIMENSIONS

FIGS. 24 AND 25. SIGNS OF DIRECTION AND THE APPLICATION OF DIMENSIONS.

105. In Fig. 21 is an example of "center line dimensioning," such as draftsmen have been known to send to the shop. While these dimensions are often of value to the draftsman when laying out a design, and may be useful also to the pattern maker, they are seldom of much value to the machine shop, especially if the center line happens to be entirely "atmospheric." Fig. 22 exhibits a good dimensioning of a flange coupling. Fig. 23 is in the nature of a "key" to this dimensioning, with explanatory notes.

106. Before passing to a consideration of the application of dimensions, the reader's attention is directed to the three Signs of Direction in Fig. 24. The "pointer" there shown deserves a word or two. Its

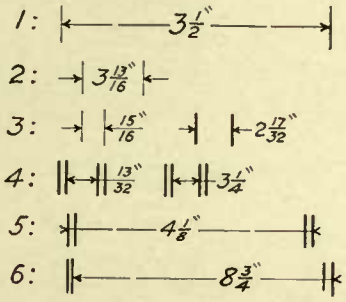


FIG. 26. SIX DIMENSION CONSTRUCTIONS.

purposes are stated, and in Fig. 25 several applications are illustrated. The main feature of it is the single-barb head, by which it is easily distinguished from the end of a dimension line. The single barb also enhances its efficiency as a clear and definite pointer. Its uses should not be confused with those of the Indicator or the Arrow.

107. THE APPLICATION OF DIMENSIONS.—In Chapter III. six "dimension constructions" were given. For convenience, they are repeated here in Fig. 26. The purpose of these constructions is to make it impossible for a dimension to be misunderstood. Fig. 25 shows them ap-

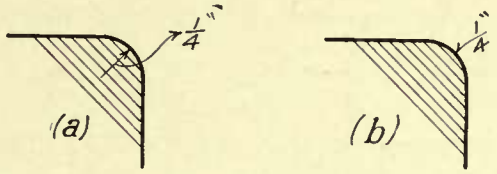


FIG. 27. WRONG AND RIGHT WAY OF INDICATING RADIUS OF ROUNDED CORNER.

plied to circles and circular arcs—diameters and radii. In the work of the average draftsman it is not at all uncommon to find the radius of a rounded corner given as at (*a*) Fig. 27. The arrangement shown at (*b*) is much simpler—so simple, indeed, that draftsmen have been known to object, on the ground that it is in some way ambiguous; yet there can hardly be any doubt as to its meaning; it is, in fact, a perfectly rational way of indicating such a radius. It is seldom necessary actually to mark the center of a rounded corner or fillet, because the position of the center itself is of no practical value to anyone; what the drawing should give is the nature of the curve, and this is done completely by specifying the radius length. In (*a*) the draftsman has used a pointer of absurd shape; that is what it really amounts to.

108. Fig. 28 shows how dimensions may be applied to a drawing of a shaft. The view has been made to serve efficiently as a vehicle for the required dimensions; it is best to put the bulk of the dimensions *above* the view, because when the shaft is in the lathe it is only the up-

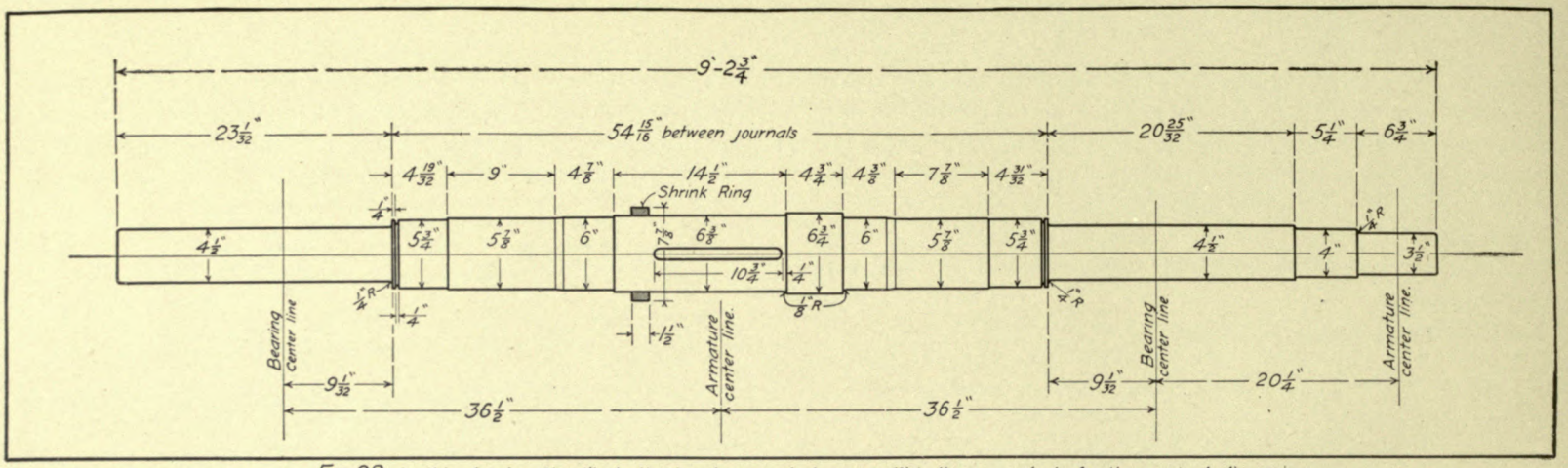


FIG. 28: In this drawing the illustration has been made to serve efficiently as a vehicle for the required dimensions

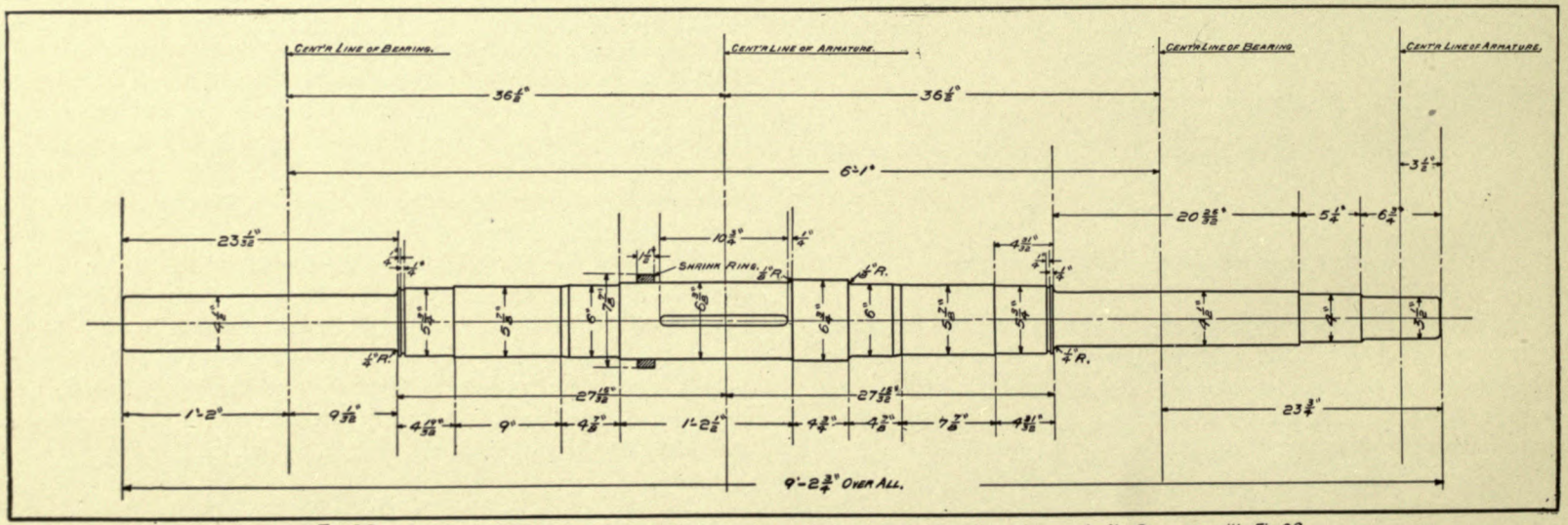


FIG. 29: Reproduced from an actual working drawing; showing how not to dimension a shaft. Compare with Fig. 28.

FIGS. 28 AND 29. RIGHT AND WRONG METHODS OF DIMENSIONING A DRAWING OF A SHAFT.

per half of it that is visible; and it is reasonable to put the bearing center distances *below* the view, because in the complete machine the bearings will be under the shaft. Fig. 29 is reproduced from a drawing made by a draftsman who did not know how to dimension this shaft. Dimensions that are thus thoughtlessly applied are almost always difficult to find, which means that time is lost and somebody's patience tried whenever the drawing is referred to. It is not right that a machinist should be put to unnecessary trouble in order to read a drawing; he will do more and better work from a drawing that is easy to read than from one that has to be translated.

109. It will be noticed that in these drawings the dimension figure is occasionally placed as illustrated separately in Fig. 30. This is not a new arrangement. It is, however, so useful and so little used that something should be said about it. When the placing of the figure *across* the dimension line will make the drawing easier to read, it is best to place it so, because *drawings are made to be read.* It is true that

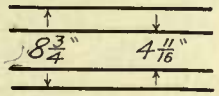


FIG. 30. AN OCCASIONALLY USEFUL WAY OF FIGURING A DIMENSION.

generally the figure may lie *with* the dimension line, but when some other arrangement would be more readable it should be used; certainly *tradition* should not be allowed to stand in the way. In our every-day work we are all more or less slaves to tradition; a little flexibility is a good thing, and will often help the draftsman out of a tight place.

110. It would not be difficult to find grounds for advocating a more general use of the arrangement just referred to. In Fig. 22 *all* the dimensions are so arranged, and are certainly very easy to read. However, it would not be wise to altogether abandon the older method; it is probably better to use both, each where it seems right; though, after all, this is a matter rather of style than anything else, and does

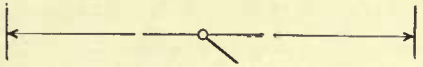


FIG. 31. A SUBSTITUTE FOR REPEATING A DIMENSION.

not affect any principle. Fig. 31 contains a suggested substitute for repeating a dimension. The greatest objection to repeating arises when a *change* is to be made; then, if by any chance a "repeat" is left unchanged, trouble may ensue. This special application of the Indicator is suggested, not because any general use of it is recommended, but in order that the draftsman may have such a device at his command: it sometimes helps.

111. It is impossible to lay down hard-and-fast rules for applying dimensions, because we are not dealing with an exact science, but the following may be taken as in a general way summing up the requirements:

(1) The illustration should be made to serve efficiently as a "vehicle," carrying the dimensions naturally; that is, with due regard to the manner in which the work will be handled in the shop, or the dimensions used elsewhere.

(2) Every dimension should be placed where there is clear room for it, and the construction chosen to suit the lines of the drawing and the space at disposal.

(3) Dimensions for one workshop should not be indiscriminately mixed with those for another.

(4) A dimension should not be repeated unless doing so will in some way make the drawing easier to understand.

112. Assuming sufficient knowledge and experience, a little intelligent thinking will enable the draftsman to meet these requirements; not in every detail, and not in such a manner as to defy criticism, but certainly to an extent that will repay for the effort required. The dimensionings given of the spider, the shaft, and the coupling were worked out with considerable care, and are *actual*, not imaginary, examples, being reproduced with very few changes from working drawings made some years ago. It is hoped that they will be of some assistance to the student of this interesting language, by showing him that by simple means it is possible to make drawings that are in every way a pleasure to read.

113. Not many years ago the writer knew a young man who entered the employ of a large engineering concern as "tracer." He had previously been a salesman in a dry goods store, but was ambitious, and under the coaching of a friend had acquired some dexterity in the handling of drafting instruments, notably the tracing tools. He was naturally a good penman, and was soon able to make tracings that passed muster; and, being industrious, he finally became quite "expert," turning out neat work rapidly. By and by he was promoted to a position at the drawing board and was permitted to make detail drawings in pencil, and even to "dimension" them; in fact, was duly enrolled in the ranks as draftsman. In other words, this man, who had scarcely seen the inside of a machine shop, and actually did not know a lathe from a radial drill, was paid so much an hour for preparing "illustrated specifications" for the use of the shop.

114. In the face of this as a fact, is it surprising that there is some misunderstanding as to the real significance of the term draftsman, and some doubt as to his rank in the engineering professions? His cry for professional recognition is not without reason, but it can be of little or no avail until he is able, without supervision, to do his work as it should be done.

115. It is perhaps not too much to say that the successful draftsman of the future must be first of all an engineer, and then that his ambition must be not to get away from the board, but to develop his powers at the board, so that he may do better designing and make more efficient drawings of every kind. Of course, so long as the really efficient draftsman is as rare as he is to-day, he will continue to be called upon to assist the rank and file, and it will continue to be necessary, for economic reasons, to use him as a chief draftsman or foreman and to have working under him the draftsman of smaller caliber, whose duty it will continue to be to receive instructions, obey orders, and work under constant supervision in all matters pertaining to the drawing as the writing of a language and as a "tool" for the use of the shop. And so long as our educational institutions separate mechanical drawing as a study from designing, the language from the writing and use of it, and graduate men who look with contempt upon the making of mere drawings, and consider any time they may have to spend at the board as an irksome preliminary to their advent as "engineers," so long will the graduate neglect to study drawing as it should be studied.

116. It seems as though the average draftsman of to-day is either not a student at all or is a student of something else than drafting: either unconsciously willing to go to seed as a "draftsman pure and simple" or ambitious to get away from the board altogether and be something other than draftsman, though just what that something

might be he would often be puzzled to state. Far too many draftsmen are only theoretically ambitious, and neglect to see in their own work the direct road to success; it is their attitude toward their work that is at fault.

117. There is to-day a great field in the world of engineering for the really efficient draftsman: the one who loves his work at the board, who feels that drafting is a profession to be proud of, and who has made and continues to make a systematic study of the many branches of engineering that find expression in his work.

118. In the first place, he should be able without extraordinary effort to make an absolutely accurate layout; should be familiar with the principles of geometry and able to solve such mathematical problems as may present themselves. He should be well grounded in physics and broadly and intimately familiar with the elements of machine design; notably, perhaps, every known form of fastener, bearing, and means of transmitting motion and power; also of such mechanical contrivances as are most commonly used in machinery. He should be able to make a reasonably good free-hand sketch, and, not by any means of least importance, he should be able to make a vivid mental picture of what he draws, and see in detail the results that will finally ensue in the shop. Outside of all this, he should have a clear conception of the business relations of the drawing with the shop and other departments. He must also keep abreast of the times in matters relating to shop practice, processes of manufacture, and shop and office systems.

119. Nothing less than this will enable him to handle the language efficiently or to find lasting pleasure in his work. And possessing such knowledge, he will no longer have to spend his every working hour doubled up like a half-closed jackknife over the edge of a pine board, but will find extended to him a pleasurable and profitable variety of work.

CHAPTER VIII. THE RECORD STRIP.

120. A mechanical drawing—by which is meant the "illustrated specification," as defined in Chapter VII., paragraph 95—is not complete until it has been titled and numbered.

121. In drafting rooms the world over it has long been customary to allow the title to include, in addition to a description of the contents of the drawing, the name and address of the firm; and also to have it carry the drawing number, the scale of the work, the signatures of those who shared in making the drawing, and the date of completion.

122. A generation ago draftsmen were permitted to elaborate these titles by the use of ornamental lettering and other more or less artistic embellishment; in fact, the title was often a very conspicuous feature, being executed according to the individual taste of the draftsman, who

would appear to have had more spare time than he knew what to do with. Such a title, made about thirty-five years ago, is shown in Fig. 32. It occupied the lower right-hand part of the drawing, and covered fully one-eighth of the entire sheet.

123. The form of title used to-day by a modern firm of machine tool builders is shown in Fig. 33. In this, neatness and uniformity are assured by having those parts that are common to all titles press-printed in the lower right-hand corner of the sheet, ready for the draftsman to fill in. This title has an official appearance entirely lacking in Fig. 32; it also carries records of changes and other data of value.

124. These may be taken as typical examples of titles ancient and modern. At first sight they appear to offer a great contrast; but it is almost at once evident that they differ in appearance and design rather than in general character, although the one does carry certain record data not found in the other. A serious fault common to both—and common to titles in general to-day—is that they are designed to occupy the lower right-hand corner of the drawing, thus rendering a valuable part of the sheet permanently unavailable for drawing on, whether convenient or not; and another fault—also common to titles in general—is that they are collections of dissimilar items.

125. There is no valid reason why the name and address of a firm, the number and scale of a drawing and the place where it is filed, the dated signatures of several draftsmen, sundry order numbers, data regarding changes and pieces affected, and a description of the contents of a drawing, should be crowded together into a kind of potpourri design and christened "title." It is an attempt to mix things that should be separated—probably the result of conservatism, that unconscious tendency in drafting rooms to stand by old traditions.

126. Fig. 34 shows what can be done by systematically distributing these items as "record data" over a narrow strip extending across the entire foot of the drawing. By this arrangement a clear rectangle is always available for drawing on, which is as it should be; and the record strip affords ample space for all necessary records. The exact nature of these records—in other words, the contents of the record strip—cannot be defined in such a way as to fully meet the varied requirements of all drafting rooms, but the following will serve as an example of what the contents may be, to be modified according to the conditions existing in any particular drafting room:

(1) Firm name and address.
(2) Title—descriptive of the contents of the drawing.
(3) Drawing number.
(4) Scale.
(5) Dated signatures of those who took part in the making of the drawing.
(6) Dated O. K. signature of the person, generally the chief draftsman, who is officially and finally responsible for the drawing.
(7) Sub-numbers.
(8) First order number, or its equivalent, in connection with which the drawing, as defined by each sub-number, is used.
(9) Records of changes for which new sub-numbers were given.

127. Of these items the first six do not call for special comment; the last three do, because they directly influence the permanent and uninterrupted efficiency of every drawing *after it has once been changed from the condition in which it was originally used*; and there are compara-

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tively few drawings made that do not require changing at one time or another.

128. One of the most prolific sources of trouble in the modern drafting room and shop is this changing of drawings; especially when the change and filed away for future reference, but it would be out of place to enter into any consideration of them here. Whatever system is used, the drawing itself—the tracing—should carry some record of every change, even though it be no more than the date of the change, with a

FIG. 32. REPRODUCTION OF TITLE OF AN OLD DRAWING.

30" MOTOR-DRIVEN LATHE

General Assembly

THE LODGE & SHIPLEY MACHINE TOOL COMPANY

CINCINNATI, OHIO.

ORIGIN H.C. Brown	PENCILED B.E. Robins				TRACED W. Laughlin				
FIRST LOT NO. 12642	FIRST SHOP NO. 6320				LAST NOS				
Alteration Dates	7.16.03								
PIECE NOS. AFFECTED	241 242 243 262 307								
1ST LOT & SHOP NOS.	13421	7371							
Proposed by: Made by:	H.S.	H.E.K.							

SCALE: 1/4

DATE 6.11.02 DWG. NO. 16437

DRAWER NO. 78 O.K. H.M.K. 18 Sheets. No. 15

FIG. 33. REPRODUCTION OF A MODERN DRAWING TITLE.

change affects a piece that has to be supplied for repairing a machine built prior to the making of the change. In such a case, if there is any doubt as to what the drawing specified before the change was made, annoying troubles are almost sure to follow.

129. There are many ways in which drafting rooms take care of such changes, as by the use of special record prints made prior to the list of the pieces affected and the order number in connection with which the changed drawing was first used. A very simple way of doing this is illustrated in Fig. 34. The original drawing—that is the drawing *as first used in the shop*—is called Sub No. 1. Then when a change is made that in any way affects work to be done in the shop or the interchangeability of any piece, the drawing is given Sub No. 2,

A B

4378

EXPLANATORY.

In this illustration the rectangle ABCD represents the drawing trimmed to size, and EFCD is the Record Strip completely filled in as an example.

The depth ED of the strip, which for very small drawings may be about 1", may conveniently be the same for all drawings of the same size.

The strip should be divided into rectangular spaces suited to the contents, which in this example may be specified as follows:-

Dwg. No.	FIRM NAME AND ADDRESS				Scale	Dwg. No.
Draftsman's Signature Dated	SUB No.	First Order No. O.K. Signature, dated	SUB NO.	First Order No. O.K. Signature, dated.	TITLE	
Tracer's Signature Dated	Statement of what the drawing was under this Sub No.; that is BEFORE the change was made.					
Checker's Signature Dated						

The drawing number, which should be in bold and clear figures, appears not only at each end of the strip, but also at the extreme upper left hand corner A of the sheet, where it is inverted, so that when a drawing happens to be piled up with others wrong way around its number may always be read right way up in the same relative position on the sheet — the lower right hand corner.

Those parts of the strip that are common to all the drawings of the same firm may with advantage be press printed on the tracing. This helps to uniformity.

E F

4378	THE AMERICAN MACHINE CO., Pittsburgh, Pa., U.S.A.		Scale ¼ 4378
Draftsman: J.B. Brown 3-2-05	1 1st Order No. 7142 O.K. 76/Md. 3-5-05	2 1st Order No. 8639 O.K. 76 MK 2-16-06	48" TRIPLE-GEARED LATHE. MOTOR DRIVEN
Tracer: John Williams 3-4-05	Clutch Ring was C.I. Sleeve was 3" long. Piece 326 was ⅞" dia.		VARIABLE SPEED MECHANISM. DETAILS.
Checker: W.Smith. 3-4-05			

D C

FIG. 34. THE RECORD STRIP.

redated and signed, and under Sub No. 1 a record is made of what the drawing was *as* Sub No. 1; that is before the change was made necessitating the use of Sub No. 2. When this system is used it must be understood by all concerned that references to drawing numbers always mean the *latest* Sub No., unless otherwise specified. Other suggestions regarding the use of the record strip will be found in Fig. 34.

CHAPTER IX. NOMENCLATURE AND WRITTEN MATTER.

130. In addition to the contents of the record strip, almost all mechanical drawings carry more or less written matter, as names of pieces, designations, bills of material, explanatory notes, references, and special instructions; all of which depend largely for their efficiency upon the draftsman's common sense and knowledge of nomenclature.

131. Early in 1905 it was the writer's privilege to prepare a pamphlet on nomenclature for the Westinghouse Electric & Mfg. Co. The opening paragraphs of this pamphlet read as follows:

> It is extremely desirable that there shall be, throughout the business of the company, uniformity in the naming and describing of apparatus; in other words, uniformity of nomenclature.
>
> The word nomenclature, as here used, means "full descriptive name," and covers three features:
>
> (1) The individual terms, or "items" of a name.
>
> (2) The sequence of the items.
>
> (3) The phrasing of the items.
>
> The system of nomenclature outlined here is intended to affect names, titles, indexing and filing, throughout the Engineering Department, and especially in connection with the following:
>
> Naming of complete apparatus and of parts and details.
>
> Wording and arrangement in printed forms and on nameplates.
>
> Writing of specifications.
>
> Subjecting of correspondence.
>
> Titling of drawings.
>
> Titling and wording of catalogues and circulars.
>
> Indexing and filing in general.

132. The pamphlet is thumb-indexed, so that the name of any machine or apparatus can be referred to instantly. The official method of description is read from numbered columns of classified data, as shown in Fig. 35, which is a reproduction of the page devoted to circuit breakers. The sequence of items is obtained by reading "down" as numbered under "items." Items connected by dashes are the equivalent of a *single* item, and may be termed a "set"; except when part of a set no two items from the same line can be used at once. The preferred "phrasing" is indicated in the table by numbers under that head; the system of nomenclature requires the use of one written line per phrase, as in the following example description of a circuit breaker:

> Circuit breaker: carbon: type A.
> Hand operated: overload release.
> Five amperes: 120 volts, D. C.
> Four poles: 16-in. throw.

In this example the items, their sequence and phrasing are in accordance with the table.

133. In the titling of a drawing it is not always desirable to use a full description of the apparatus; none but orthodox names should be used,

Phrases	Items	Name
1	1	CIRCUIT BREAKER
	2	Carbon : Oil : Fused : Mag. Blow Out : Air
	3	Type (aa, A, B, C, D)
2	4	Hand Operated | Elec. Operated | Pneumatic
	5	Front Connection : Rear Connection
	6	Swbd. Mounting : Wall Mounting : Direct Control
	7	Overload: O. L. and O. V. / Underload: U. L. " U. V. / Over Voltage: Non-Automatic / Under Voltage: } Release
3	8	——Amps.——Volts A.C.——Volts D.C.
4	9	——Poles——Throw

Circuit Breakers

FIG. 35. SAMPLE PAGE OF WESTINGHOUSE PAMPHLET ON NOMENCLATURE.

however; and when possible the official sequence and phrasing of the items should be employed, as in the following example title:

Circuit Breaker: carbon: type A
Hand operated: overload release
General Drawing

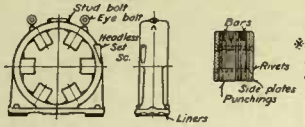
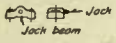
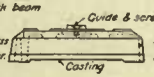
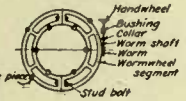
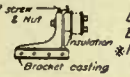
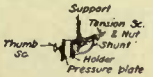
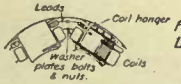
134. Just how it came about that the matter of nomenclature received this special attention from the Westinghouse Company has so direct a bearing on the leading features of this chapter that a brief account may not be out of place here.

135. In 1899 the drafting room of the above company was finding employment for something over one hundred men, and up to that time about 25,000 drawings had been made and put on file. The chief draftsman, a Mr. John W. Meserve—then newly appointed—a man of great executive ability and of long experience in the managing of large drafting rooms, was dissatisfied with the lack of system that he found, but it was impossible for him to devote time to a thorough investigation. The making of this investigation fell to the writer's lot. A study of conditions revealed among other things much confusion in the matter of nomenclature. Different men called the same thing by different names, or what was quite as bad, meant different things by the same name; and drawings that were titled similarly did not contain similar parts; so that the drafting room, office, and shop were continually misunderstanding one another.

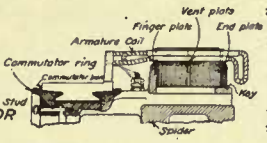
136. An important step was made leading toward a system of nomenclature when the first "element chart" was developed, as reproduced here in Fig. 36. This is one of about thirty that were compiled. Each machine was divided into "elements," each element consisting of certain specified details, and every part was officially named. With these charts in their possession draftsmen had no excuse for using irregular names or titles, and their influence was soon felt throughout the factory, so that in talking or writing about details of construction there came to be less and less misunderstanding, and a much more harmonious condition prevailed.

137. These element charts almost immediately led to the adoption, for each type of machine, of special printed lists—called "drawing lists"—for the transmission of information from the drafting room to

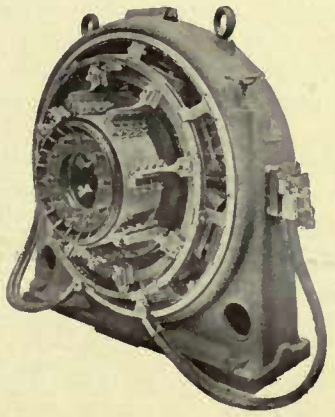
STATIONARY PART

ELEMENTS		DETAILS
FRAME		Frame castings. *Poles { Punchings, Side plates / Bars, Rivets Headless set screw for locating worm shaft bushing. Stud-bolt & nuts. Eye-bolts. Liners.
JACK		Jack beam & screw.
BED PLATE { Not furnished unless special Stock order.		Bed plate casting. Guide & screws. Bed plate bolts & nuts. (both for frame & jack).
ROCKER RING		Ring castings. Stud-bolts & nuts. (when ring is in halfs) Guide pieces & tap-bolts.
ROCKER RING GEAR		Worm wheel segment. Tap bolts. Worm. Worm shaft. Bushing. Collars. Pins *Handwheel.
BRUSH CROSS CONNECTIONS		Copper rings. Cleats, Bolts, etc. *Contact plates. *Terminal plates.
BRUSH HOLDER BRACKET		Bracket casting. Set screw & nut. Bolts for bracket, contact plate & brush holders. *Insulations, washers & washer-plates.
CARBON HOLDER		Holder. Support. Pressure plate & thumb screw. Tension spring. Screw & nut. Shunts. Screw & washer. Shaft. Bush & taper pin.
CARBON		Carbon brush.
TERMINAL BOARDS		Base. *Contact blocks. Bolts & washers.
FIELD WINDING		Field coils. Coil hangers, bolts & washers. Leads. Strips. Bolts. Washer plates & nuts.
WIRING AROUND FRAME		Shunt, series & cable connections. Cleats & screws. Bolts. Ferrules & rubber washers for attaching term bd *Terminals. *Name plates.
LAMP CIRCUIT		Chandelier. Lamps. Cleats. Lamp wire.

ROTATING PART

ELEMENTS.		DETAILS
ARMATURE COMMUTATOR		*Spider casting. *Punchings. *Ventilating plates *Finger plates. *End plates. Keys. *Commutator bars. *Commutator ring; studs, nuts & washers Insulation.
ARMATURE COIL		See Elec. & Insulation Specification.
ARMATURE COIL SUPPORT		Casting & screws. Insulation & rivets.
ARMATURE CROSS CONNECTIONS		Cleats. Studs. Connectors. Cables.
SHAFT (Not usually furnished)		Shaft. Keys.

* Parts marked thus are detailed separately.



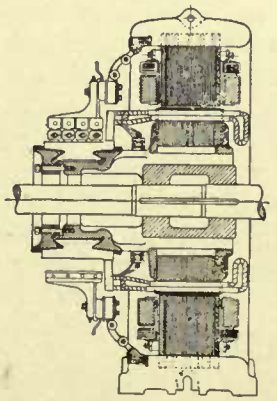


FIG. 36. AN "ELEMENT CHART."

the shop. This was another step in the right direction. In these lists the correct names of the parts were arranged in the same order as on the charts. Finally in order to insure uniformity in the *describing of complete apparatus*, the pamphlet on nomenclature was written.

138. Very little need be said here about *how* to give a name to a piece of machinery, except, perhaps, that it should never be done thoughtlessly. While a new machine is being designed, it should be divided into natural or suitable "elements," and these into "details" sensibly named. It is not at all uncommon to find included in the name of a piece the name of a *material*. This is distinctly poor practice. The already established principle that "drawings should be made right to stay right" has a direct application here; if, for instance, terms like "wooden ring," "fiber washer" are allowed to creep in, and it is decided later—we will say a year later after all catalogues and circulars have been issued *using these terms*—that the ring is better of fiber and the washer of brass, there have been introduced two very absurd names, for we shall have a wooden ring made of fiber and a fiber washer made of brass; and it will not be at all an easy matter to stop the use of these names.

139. In most drafting rooms the naming of parts and details—where names are used in preference or in addition to numbers—is done without sufficient consideration; a habit of carelessness too often prevails, the result being names that do not fit and that cause trouble in many little annoying ways. The remedy lies almost entirely in a personal appreciation of the necessity of using care.

140. But the *name* of a piece is only a part of what may be called the draftsman's *designation* of it, which often includes several items, as dimensions, material, finish, and quantity required. Taking the last of these: On the first thought it would not seem difficult to find one way —one universally acceptable way—of specifying quantity required; and yet an examination of the drawings made by different men in different drafting rooms revealed a variety quite surprising in its range. The following are some of the different ways in which English-speaking draftsmen have specified required quantities in actual working drawings made during the past fourteen years:

3	Take 3
Three	Use 3
3 wanted	Get 3
3 needed	3 thus
3 of these	make 3
3 of them	Want 3
3 of this	3 required
3 off	3 like this
3 of	3 per machine.

141. And this variety in the term is supplemented by changes of its position in the complete designation; thus, taking a simple example, a complete designation may read:

Make 3 Dowel pins ½-in.×3¼-in.
or ½-in.×3¼-in. Dowel pin, make 3
or Make 3—½-in.×3¼-in. Dowel pins.

142. But to return to the manner of specifying quantity required; during the investigation already referred to it was finally decided to use "Require"—abbreviated "Req."—and to follow it by the quantity number, as Req. 3: the great advantage of this word is that it is general in its significance, for whether a piece has to be made, or bought, or taken from stock, it is always "required." It was further decided that in all designations this should be the last item, thus:

½-in.×3¼-in. Dowel Pin: Req. 3.

The designations given below are representative examples for draftsmen to imitate. Many of them follow commercial usage. As a general rule, in specifying pieces of raw material, as wire, rod, sheet and strap, the thickness or diameter is given <u>after</u> the other dimensions; in specifying finished articles, as screws, bolts, rivets and escutcheon pins, the diameter should be given <u>first</u>.
In these examples, to avoid tiresome repetition, the "quantity required" is generally omitted.

FASTENERS

- $\frac{1}{2}$" x $3\frac{1}{4}$" Dowel pin, Req.3
- $\frac{7}{8}$" x $6\frac{1}{2}$" M.B. Mach.B., Req.15
- $\frac{3}{4}$" x 9" Stud, Req.38
- $\frac{5}{8}$" x $2\frac{3}{4}$" M.B. Tap.B., N.P. Req.8
- $\frac{5}{8}$" x $1\frac{1}{2}$" Cap Sc., C.H.Hd.
- $\frac{3}{16}$" x $1\frac{3}{4}$" Spring Cotter
- #16 x $\frac{3}{8}$" Escutcheon pin
- $\frac{3}{8}$" x $\frac{1}{2}$" x 4" Feather key, steel, Req.2
- $\frac{3}{8}$" x $2\frac{1}{2}$" Lag Sc.
- $1\frac{1}{4}$" Hex. Nut
- $\frac{5}{8}$" Lock nut
- Wing nut, #73, Req.8
- $\frac{1}{4}$" x $1\frac{1}{4}$" Rd. Hd. I. Rivet
- #$7\frac{1}{4}$ x $\frac{1}{2}$" Flat Hd. I. Rivet
- $\frac{3}{16}$" x $\frac{1}{4}$" Flat Hd. Csk. Copper Rivet
- #9 x $\frac{3}{8}$" Copper belt-rivet
- $\frac{3}{32}$" x $\frac{5}{16}$" Copper jacket-rivet
- $\frac{1}{8}$" x $1\frac{1}{16}$" Pin, C.R.S., Req.31
- #14-24 x $1\frac{1}{2}$" Fil. Hd. B. M.Sc.
- Hex. Hd. Set Sc. #248, Req.60
- $\frac{1}{2}$" Eye bolt, Req.1
- Jack Sc. #743, Req.1
- $\frac{1}{2}$" x 1" Hdless. Set Sc. C.H., Req.2

INSULATING MATERIALS

- $3\frac{9}{64}$" x $5\frac{13}{32}$" x $\frac{1}{16}$" Sh. Asbestos, Req.3
- Distance piece, 24" x 12" x $\frac{1}{8}$" fibre
- $\frac{7}{8}$" x $\frac{3}{16}$" Rod, red fibre, Req.6
- 3 Layers of .056 F.B., for building up coils to $1\frac{1}{4}$", Req.16
- 3 Layers of .056 F.B., Treated and cemented together with shellac.
- $1\frac{5}{8}$" x $3\frac{7}{16}$" x $\frac{1}{32}$" Mica, Req.8
- 5" x $\frac{3}{4}$" Rod, semi-hard rubber.
- 22" x 36" x 2" Soapstone

ROD

- $1\frac{1}{4}$" x .085 Drill rod, Req.3
- #6-32 Nut, from $\frac{3}{16}$" x $\frac{3}{8}$" Hex. B. Rod.
- From half round .162 B. Rod, $\frac{1}{2}$" long.

SHEET & PLATE

- Punchings of .0172 sheet steel
- .0625 Steel, 3 at each end, Req.6
- 24" x 82" x $\frac{3}{8}$" Plate, steel, Req.4

TUBING

- $3\frac{3}{4}$" of .8718 x 1" Seamless B. Tubing
- $\frac{3}{16}$" x $\frac{1}{4}$" W.I. Pipe, Req. $21\frac{1}{2}$"

MISCELLANEOUS

- $\frac{1}{4}$" Lock washer, Req.3
- $8\frac{1}{2}$" of .007 G.S. Wire, Req.6
- 10 Turns of .024 Music wire, Req.8
- #12 Torpedo twine, Req. 20 Ft.
- 1" x $\frac{1}{4}$" Felt; cut to suit, Req.3
- 1" x $4\frac{1}{2}$" x $\frac{1}{2}$" Pad, Leather.
- $\frac{3}{8}$"-16 Thds.
- #24-16 Tap.
- $\frac{5}{8}$" Tap, 11 Thds. per inch.
- .201 Drill & $\frac{7}{16}$" Cbr., $\frac{3}{8}$" deep.
- Made from $1\frac{1}{2}$" x $\frac{1}{16}$" Copper strap, about $2\frac{3}{8}$" long, Req.3.
- Taper 1".219 per foot on diameter.
- 3" x 10" x $\frac{3}{4}$" Hard wood, Req.2

The above examples indicate when a word should begin with a capital letter. In general, capitalize the first word in a designation, all abbreviations, and the word immediately following an abbreviation.

An explanatory or descriptive note added as auxiliary to the designation should be placed <u>under</u> the designation, so as to leave the "quantity required" at the end of a line, thus:-

$\frac{3}{4}$" x 6" Tap B., Head S.F. & Blued, Req.8
For securing bracket to leg.

FIG. 37. EXAMPLES OF DESIGNATIONS.

PHYSICAL QUANTITIES: Symbols.

Length	L, l
Mass	M
Time	T, t
Surface	S, s
Volume	V
Velocity, linear	v
" angular	ω
Acceleration	a
Force, or Weight	F, f
Work	W
Power	P
Pressure	p
Moment of inertia	K

METALS

Aluminum	Almn.
Babbitt	Bb.
Brass	B.
Bronze	Bz.
Carbon	Cbn.
Cast brass	C.B.
Cast copper	C.Cop.
Cast iron	C.I.
Cast steel	C.S.
Cold rolled steel	C.R.S
Copper	Cop
Lead	Lead
Malleable iron	M.I.
Open hearth steel	O.H.S.
Phosphor bronze	Ph. Bz.
Steel	Steel
Steel casting	S.C.
Wrought iron	W.I.
Zinc	Zn.

GAUGES

Brown & Sharpe, or American Standard Wire Gauge	B.&S.
Birmingham, or Stubs' Iron Wire Gauge	B.W.G.
National, or Roebling's, or Washburn & Moen's	N.W.G.
Music Wire Gauge	M.W.G.
United States Gauge	U.S.G.
Twist Drill & Steel Wire Gauge	T.D.G.
Stubs' Steel Wire Gauge	S.W.G.

THE MONTHS

Jan. Feb. Mar. Apr. May. June.
July Aug. Sept Oct. Nov. Dec. Dec. 3. 06

TIME

By the clock	$2^h\ 15^m\ 46^s$
Duration	2h. 15m. 46s.

FASTENERS

Button head bolt	Btn. Hd. B.
Cap screw	Cap Sc.
Double chamfered hexagon nut:	Dbl. Chmfd. Hex. Nut
Eye bolt	Eye B.
Fillister head brass machine screw:	Fil. Hd. B. M. Sc.
Fillister head iron machine screw:	Fil. Hd. I. M. Sc.
Flat head wood screw	Flat Hd. Wd. Sc.
Flat head stove bolt	Flat Hd. Stove B.
Headless set screw	Hdlss Set Sc.
Hexagon nut	Hex. Nut
Lag screw	Lag Sc.
Machine bolt	Mach. B.
Machine screw nut	M. Sc. Nut
Milled body tap bolt	M. B. Tap B.
Set screw	Set Sc.
Square nut	Sq. Nut
Stud bolt	Stud B.
T-head bolt	T-Hd. B.

WEIGHTS & MEASURES, etc.

Center	Cr.
Center line	~~Cr.~~
Centimetre	cm.
Circular mils	C.M.
Circumference	Circum.
Diameter	dia.
Electromotive force	E.M.F.
Foot, feet	Ft.
Horsepower	HP
Inch, inches	In.
Kilogram	Kg.
Kilometre	Krm.
Kilowatt	KW
Millimetre	mm.
Ounce, ounces	Oz.
Pound, pounds	lb.
Radius	Rad. or R.

※ Here the meaning of the abbreviation depends entirely upon how it is used. This is largely true of most abbreviations. ≠

In "a lamp of 16 C.P." it is perfectly evident that the meaning is 'candle power.'

In "a gear of ¾" C.P., 72 teeth," it is just as evident that the abbreviation means 'circular pitch.'

MISCELLANEOUS

Alternating current	A.C.
Amperes	Amp.
Board	Bd.
Bracket	Bkt.
Building	Bldg
※ Candle power	C.P.
※ Circular pitch	C.P.
Case harden	C.H.
Company	Co.
Counterbore	Cbr.
Countersink	Csk
Cylinder	Cyl.
Degrees Centigrade	10°C
Degrees Fahrenheit	10°F
Department	Dept.
Direct current	D.C.
Drawing	Dwg.
Electrical	Elec.
Experiment	Exp.
Feather	Fthr.
Flexible	Flex.
General	Gnl.
Hexagon	Hex.
Machine	Mach.
Manufacturing	Mfg
Material	Mtl.
Maximum	Max.
Minimum	Min.
Negative	Neg.
Not to scale	N.T.S.
Nickel plate	N.P.
Number: For designating	No. or #
Number: Quantity	Nbr.
Pattern number	Pat. #3178
Per cent	%
Positive	Pos.
Railway	Rwy.
Revolutions per minute	R.P.M.
Rotating part	Rotor
Round	Rd.
Seamless	Smlss.
Sketch	Sk.
Specification	Spec.
Square	Sq.
Standard	Std.
Stationary part	Stator
Temperature	Temp.
Threads	Thds.
Weight	Wgt.

≠ Unless the words adjacent to an abbreviation unmistakably suggest its true meaning, the abbreviation should not be used.

FIG. 38. EXAMPLES OF ABBREVIATIONS.

In this arrangement there is no danger of confusing the "quantity figure" with any other figure in the designation.

143. The example designations presented in Fig. 37 are intended for draftsmen to imitate. It will be noticed that in many of them *abbreviations* are quite freely used. In this connection it is not easy to lay down any very useful principle, except perhaps to say that *it is permissible to abbreviate any term if it is quite certain that no misunderstanding will ensue.*

144. It has so long been the habit of draftsmen to designate the much used metals by their initial letters, that the custom may be looked upon as practically universal. With regard to abbreviations in general, the writer is somewhat chary of making suggestions. In designations and tabulated information—such as bills of material—they are almost a necessity, in order to get compactness; it would certainly be a hardship if draftsmen were compelled to use the full term "fillister head iron machine screw." On the other hand a promiscuous use of abbreviations in written notes should be avoided, as should any term of doubtful meaning. Some abbreviations that have been found useful are listed in Fig. 38.

145. It is often convenient to use commercial or "trade" terms on drawings. Unfortunately many of these terms and their meanings are subject to change without notice; and again the same term may have different meanings in different parts of the country; but we have as yet no recognized standard dictionary of mechanical terms, so that the whole condition of affairs is beyond the draftsman's control and is something, therefore, that it is useless for him to worry about. The draftsman should, however, know the difference between a washer and a sleeve, between a bolt and a screw, a shoulder and a collar, a lever and a link, and he should know the meanings of all the simpler mechanical terms, many of which the average draftsman of to-day uses with very little discretion. The following are a few definitions that the writer developed for his own benefit when at the board; they are given here merely as examples:

A washer is a circular plate of uniform thickness with a circular hole through the middle.

A washer-plate is a plate used as a washer that is not fully described by the term washer; thus it may be square and have several holes in it.

A lock-washer is a washer specially designed to prevent a threaded nut from jarring loose.

A collar is a ring of any shape secured around a shaft or similar part when placed there as an end bearing or stop. A shoulder should never be called a collar.

A bush is a tube of any shape that either is or is not secured to what surrounds it but that is not secured to what it surrounds.

A sleeve is a tube of any shape that either is or is not secured to what it surrounds but that is not secured to what surrounds it.

146. At a banquet given some years ago to a special graduating class in mechanical drawing, one of the guests—an engineer of national repute—spoke to the following effect:

"Don't be afraid of using the English language on your drawings; don't be stingy in the use of notes. Remember that the man in the shop is not a mind reader, and a brief note, carefully worded, will often save the shop much uneasiness. The majority of draftsmen seem to think it a sign of weakness to resort to writing, and go out of their way to avoid notes. I assure you it is not only legitimate, but absolutely necessary to make use of notes if you are to become master draftsmen. But whatever you do, word them carefully, and don't forget to indent your paragraphs; and remember that an ambiguous note is worse than none at all. Don't speak of the right-hand side of a piece, or the front or the back; mark the particular side with a reference letter; you see the man in the shop when looking at the piece may be standing on the other side of it; then what was right to you is left to him, and that may cause trouble."

CHAPTER X. CHECKING.

147. Before drawings are permitted to go to the shop they should be systematically checked. In large drafting rooms it is now quite generally the practice to have certain men do nothing else but check the work of the draftsmen. This checking is of vital importance; mistakes are not mistakes until after they have eluded the checker's eye. A drawing, like a machine or other manufactured product, is not ready for use until it has been officially inspected, and perhaps tested.

148. The following suggestions are intended as a help to systematic checking. Each feature should be taken up separately and, if possible, each phase of the work completed before passing on to the next.

1. Put yourself in the position of those who are to *read* the drawing and find out if it is easy to read and tells a straight story. Always do this before checking any individual features; in other words, before you have had time to become accustomed to the contents.

2. See that each piece is correctly illustrated and that all necessary views are shown, but none that are not necessary.

3. Check all the dimensions by scaling, and, where advisable, by calculation also.

4. See that dimensions for the shop are given as required by the shop, that is, that the shop is not left to do any adding or subtracting in order to get a needed dimension.

5. Go over each piece and see that finishes are properly specified.

6. See that every specification of material is correct and that all necessary ones are given.

7. Look out for "interferences." This means check each detail with the parts that will be adjacent to it in the assembled machine and see that proper clearances have been allowed.

8. When checking for clearances in connection with a mechanical movement, lay out the movement to scale, figure the principal angles of motion and see that proper clearances are maintained in all positions.

9. See that all the small details, as screws, bolts, pins, keys, rivets, etc., are standard and that where possible stock sizes have been used.

10. Check every feature of the record strip.

11. Review the drawing in its entirety in connection with any points that have suggested themselves during the above checking.

12. Bearing in mind the value of explanatory notes, do not fail to add such notes as your experience tells you will increase the efficiency of the drawing.

CHAPTER XI. STANDARD DATA.

149. In every manufacturing concern in the world there are certain facts and certain methods—in other words certain "data"—that are used over and over again. When these data are collected, classified, and tabulated for general use they are called *standard* data.

150. In many drafting rooms the importance of collecting standard data is recognized, but the manner of tabulating is probably not the same in any two drafting rooms in existence. This is unfortunate, because it makes it inconvenient to bind together the data collected by different men and different firms—data of general value that might otherwise be made use of in the compilation of a standard book for universal use.

151. The main objects in view here are to suggest for the adoption of drafting rooms in general a standard size for standard data sheets, and to present some methods of tabulating that have been developed with the idea of making the data easy to read.

152. The dimensions and general arrangement suggested for the sheet are given in Fig. 39, with an inset illustration of the "master tracing" which carries a special record strip for the recording of sub-number changes. The sub-numbers and their dates are repeated in the lower margin of the trimmed sheet; the same margin also carries the firm name and address, signatures and drawing number; leaving a clear rectangle for the data. The trimmed sheet is the same size as the widely known Carpenter section paper, $12\frac{1}{2}$ in. $\times$ $8\frac{1}{2}$ in., small enough to handle comfortably when bound in book form, yet large enough for the clear tabulating of data. When it is desired to file with correspondence, it is only necessary to cut off the $1\frac{1}{2}$-in. binding strip and the sheet is "letter size"—$8\frac{1}{2}$ in. $\times$ 11 in.

153. When putting together a page of data for general reference it is impossible to be too careful about the arrangement and ruling of the sheet. Data should always be easy to read, and every sheet should contain such explanatory notes as are necessary to make the meaning of it all perfectly clear.

154. Figs. 40 to 43 are four pages from the standard book of the Westinghouse Company, introduced here to illustrate certain methods of tabulating that have been found decidedly helpful. The reader will easily realize that the sheets were compiled with considerable care, but his attention is directed particularly to the *studied irregularities* in the arrangement of the columns and in the general ruling of each sheet. Thus, in Fig. 40 the columns are purposely *staggered*—this makes them stand out far more clearly than if they were all on the same level; then every fourth horizontal line consists of short heavy dashes—these are *guide lines* for the eye, and make it easy to follow horizontally from

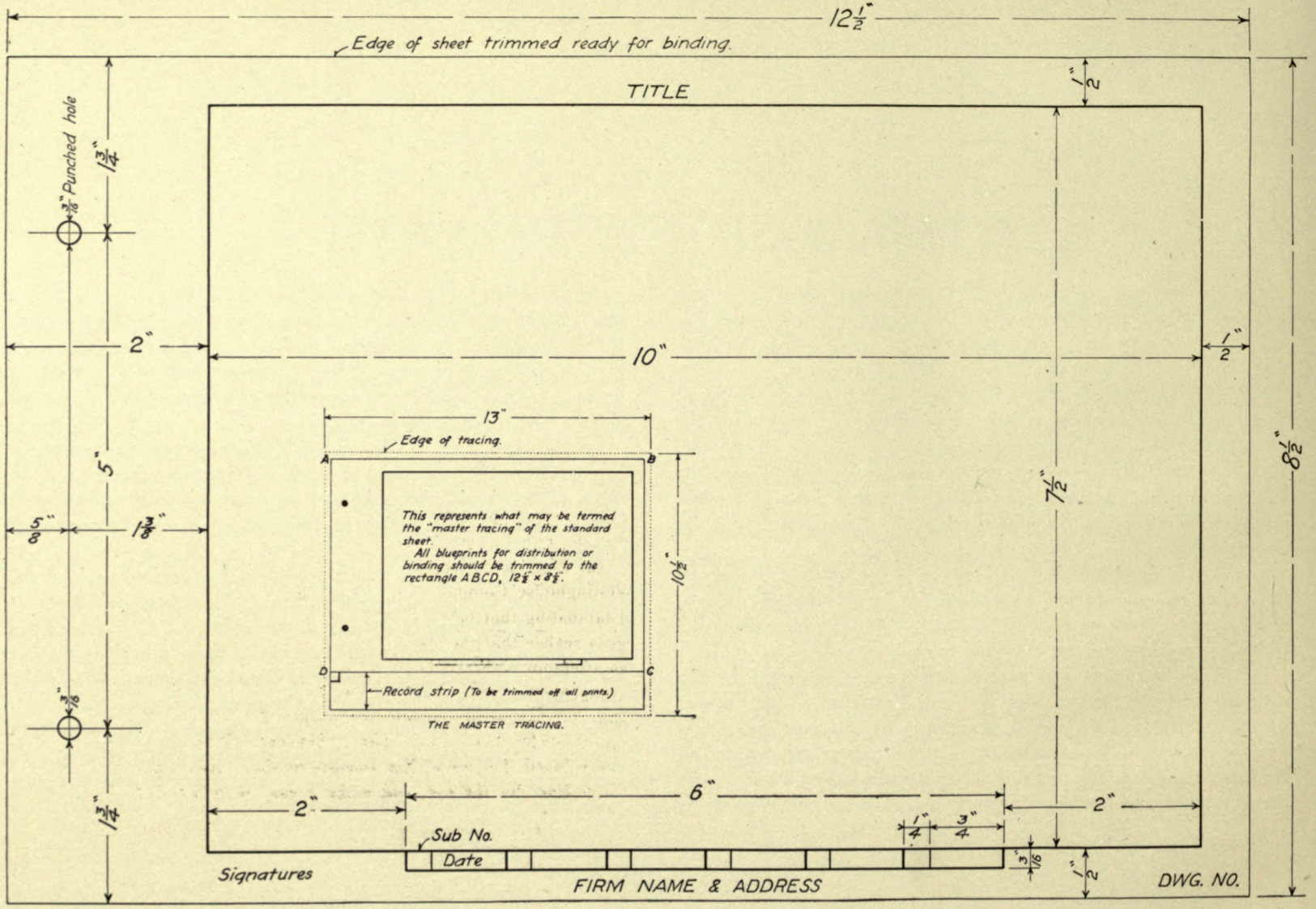
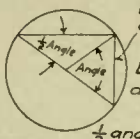


FIG. 39. DIMENSIONS AND FORM OF STANDARD DATA SHEET.

UNIT CHORDS



When diameter = 1
Chord = Sine ½ angle

EXAMPLE: When dia = 7" and the Nbr. of sides = 5: Reading from Table, ½ angle = 36°. Sine 36° = 5877852
Side = Chord = .5877852 × 7 = 4".1144964

Nbr. of Sides	½ Angle	Unit Chord.
3	60°	.8660254
3½	51°-25'-43"	.7709081
4	45°	.7071068
4½	40°	.6427871
5	36°	.5877852
5½	32°-43'-38"	.5406401
6	30°	.5
6½	27°-41'-32".30	.4647408
7	25°-42'-51".42	.4338837
7½	24°	.4067366
8	22° 30'	.3826834
8½	21°-10'-35".3	.3612528
9	20°	.3420201
9½	18°-56'-50".526	.3247123
10	18°	.3090170
10½	17°-8'-34".28	.2947622
11	16°-21'-49.09	.2817325
11½	15°-39'-7".826	.2697980
12	15°	.2588190
12½	14°-24'	.2486899
13	13°-50'-46".15	.2393157
13½	13°-20'	.2306159
14	12°-51'-25".71	.2225208
14½	12°-24'-49".65	.2149756
15	12°	.2079116
15½	11°-36'-46".45	.2013027
16	11°-15'	.1950903
16½	10°-54'-32".72	.1892537
17	10°-35'-17".64	.1837495
17½	10°-17'-8".57	.1785574
18	10°	.1736481
18½	9°-43'-47".02	.1690030
19	9°-28'-25".26	.1645945
19½	9°-13'-50".77	.1604140
20	9°	.1564344
20½	8°-46'-49".74	.1526516
21	8°-34'-17".14	.1490422
21½	8°-22'-19".53	.1455536
22	8°-10'-54".54	.1423148
22½	8°	.1391731
23	7°-49'-33".91	.1361666
23½	7°-39'-34".46	.1332880
24	7°-30	.1305262
24½	7°-20'-49"	.1278787
25	7°-12	.1253332
25½	7°-3'-31".76	.1228892
26	6°-55'-23".077	.1205367
26½	6°-47'-32".83	.1182739
27	6°-40'	.1160929
27½	6°-32'-43".63	.1139923
28	6°-25'-42".85	.1119644
28½	6°-18'-56".84	.1100094
29	6°-12'-24".82	.1081189
29½	6°-6'-6".10	.1062936
30	6°	.1045284
31	5°-48'-23".22	.1011683
32	5°-37'-30"	.0980171
33	5°-27'-16".36	.0950560
34	5°-17'-38".82	.0922683
35	5°-8'-34".28	.0896392
36	5°	.0871557
37	4°-51'-53".51	.0848058
38	4°-44'-12".63	.0825793
39	4°-36'-55".38	.0804665
40	4°-30'	.0784591
41	4°-23'-24".87	.0765492
42	4°-17'-8".57	.0747301
43	4°-11'-9".76	.0729952
44	4°-5'-27".27	.0713391
45	4°	.0697565
46	3°-54'-46".95	.0682424
47	3°-49'-47".23	.0667926
48	3°-45'	.0654031
49	3°-40'-24".49	.0640702
50	3°-36'	.0627905
51	3°-31'-45".88	.0615609
52	3°-27'-41".53	.0603784
53	3°-23'-46".41	.0592405
54	3°-20'	.0581448
55	3°-16'-21".81	.0570887
56	3°-12'-51".42	.0560704
57	3°-9'-28".42	.0550877
58	3°-6'-12".41	.0541388
59	3°-3'-3".05	.0532221
60	3°	.0523360
61	2°-57'-2".95	.0514787
62	2°-54'-11".61	.0506491
63	2°-51'-25".71	.0498458
64	2°-48'-45"	.0490676
65	2°-46'-9".23	.0483133
66	2°-43'-38".18	.0475819
67	2°-41'-11".64	.0468722
68	2°-38'-49".41	.0461834
69	2°-36'-31".30	.0455145
70	2°-34'-17".14	.0448648
71	2°-32'-6".76	.0442333
72	2°-30'	.0436194
73	2°-27'-56".71	.0430222
74	2°-25'-56".75	.0424411
75	2°-24'	.0418757
76	2°-22'-6".31	.0413249
77	2°-20'-15".58	.0407885
78	2°-18'-27".69	.0402659

1	Mar. 4. 03	2	Apr. 11. 03								

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81255

FIG. 40. SAMPLE PAGE FROM WESTINGHOUSE BOOK OF STANDARD DATA SHEETS.

WEIGHTS OF ROUND BAR PER INCH OF LENGTH.

DIA. 1/16THS INCHES	0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"
0	0	0.2223	0.891	2.01	3.57	5.58	8.03	10.93	14.28	18.07	22.31	27.00	32.13	37.70	43.72	50.19	57.10	64.46	72.27
1/16	0.00087	0.2509	0.9455	2.09	3.68	5.72	8.20	11.13	14.50	18.32	22.59	27.30	32.46	38.06	44.11	50.61	57.55	64.94	72.77
1/8	0.0035	0.2823	1.01	2.18	3.80	5.86	8.37	11.33	14.73	18.58	22.87	27.61	32.80	38.42	44.50	51.03	57.99	65.41	73.28
3/16	0.0078	0.3134	1.07	2.27	3.91	6.00	8.54	11.52	14.95	18.83	23.15	27.92	33.13	38.79	44.90	51.45	58.45	65.89	73.78
1/4	0.0139	0.3473	1.13	2.36	4.03	6.15	8.71	11.73	15.18	19.09	23.44	28.24	33.48	39.16	45.29	51.87	58.90	66.37	74.29
5/16	0.0217	0.3829	1.19	2.45	4.14	6.30	8.89	11.93	15.41	19.34	23.72	28.54	33.81	39.53	45.69	52.30	59.35	66.85	74.80
3/8	0.0312	0.4202	1.26	2.54	4.27	6.45	9.07	12.13	15.65	19.61	24.01	28.87	34.17	39.90	46.09	52.73	59.81	67.34	75.31
7/16	0.0425	0.4593	1.33	2.64	4.39	6.60	9.25	12.34	15.88	19.87	24.30	29.19	34.51	40.28	46.49	53.16	60.27	67.82	75.82
1/2	0.0556	0.5	1.39	2.73	4.52	6.75	9.43	12.55	16.12	20.13	24.60	29.50	34.86	40.65	46.90	53.59	60.73	68.31	76.34
9/16	0.0703	0.5426	1.46	2.83	4.64	6.90	9.61	12.76	16.36	20.40	24.89	29.83	35.21	41.03	47.30	54.02	61.19	68.80	76.86
5/8	0.0868	0.5869	1.54	2.93	4.77	7.06	9.79	12.97	16.60	20.67	25.19	30.15	35.56	41.41	47.71	54.46	61.65	69.29	77.38
11/16	0.1051	0.6329	1.61	3.03	4.90	7.22	9.98	13.18	16.83	20.93	25.48	30.47	35.91	41.79	48.12	54.89	62.11	69.78	77.90
3/4	0.1250	0.6807	1.69	3.14	5.03	7.38	10.16	13.40	17.08	21.21	25.78	30.80	36.27	42.17	48.53	55.33	62.58	70.28	78.42
13/16	0.1467	0.7302	1.76	3.24	5.17	7.54	10.35	13.61	17.32	21.48	26.08	31.12	36.62	42.56	48.94	55.77	63.05	70.77	78.94
7/8	0.1702	0.7814	1.84	3.35	5.30	7.70	10.54	13.84	17.57	21.76	26.39	31.46	36.98	42.94	49.35	56.21	63.52	71.27	79.47
15/16	0.2053	0.8344	1.92	3.46	5.44	7.86	10.74	14.05	17.82	22.03	26.68	31.79	37.33	43.33	49.77	56.66	63.99	71.77	79.99

DIA. 1/16THS INCHES	19"	20"	21"	22"	23"	24"	25"	26"	27"	28"	29"	30"	31"	32"	33"	34"	35"	36"
0	80.52	89.22	98.37	107.96	118.00	128.48	139.41	150.78	162.61	174.87	187.59	200.75	214.35	228.41	242.91	257.85	273.24	289.08
1/16	81.05	89.78	98.94	108.57	118.64	129.17	140.10	151.51	163.36	175.65	188.39	201.58	215.22	229.30	243.82	258.79	274.21	
1/8	81.59	90.34	99.54	109.19	119.28	129.82	140.81	152.24	164.12	176.44	189.21	202.42	216.09	230.19	244.75	259.75	275.24	
3/16	82.12	90.90	100.13	109.81	119.93	130.49	141.51	152.97	164.87	177.22	190.02	203.27	216.95	231.09	245.67	260.70	276.18	
1/4	82.66	91.47	100.72	110.43	120.57	131.17	142.21	153.70	165.63	178.01	190.84	204.11	217.83	231.99	246.60	261.66	277.16	
5/16	83.19	92.03	101.32	111.05	121.22	131.85	142.92	154.43	166.39	178.80	191.65	204.95	218.70	232.89	247.53	262.61	278.14	
3/8	83.73	92.60	101.91	111.67	121.87	132.53	143.62	155.77	167.15	179.59	192.47	205.80	219.57	233.79	248.46	263.57	279.13	
7/16	84.27	93.17	102.51	112.29	122.52	133.20	144.33	155.90	167.92	180.38	193.29	206.64	220.44	234.69	249.38	264.52	280.11	
1/2	84.82	93.74	103.11	112.92	123.18	133.89	145.04	156.64	168.68	181.18	194.11	207.50	221.32	235.60	250.32	265.49	281.10	
9/16	85.36	94.31	103.71	113.55	123.84	134.57	145.75	157.38	169.45	181.97	194.93	208.34	222.20	236.50	251.25	266.45	282.09	
5/8	85.91	94.88	104.31	114.18	124.50	135.26	146.47	158.12	170.22	182.77	195.76	209.20	223.08	237.42	252.19	267.42	283.09	
11/16	86.45	95.46	104.91	114.81	125.15	135.94	147.18	158.86	170.99	183.57	196.59	210.05	223.97	238.33	253.13	268.38	284.08	
3/4	87.00	96.04	105.52	115.44	125.82	136.63	147.90	159.61	171.77	184.37	197.42	210.91	224.85	239.24	254.07	269.35	285.08	
13/16	87.56	96.62	106.13	116.08	126.48	137.32	148.62	160.36	172.54	185.17	198.25	211.77	225.74	240.15	255.01	270.32	286.07	
7/8	88.11	97.20	106.73	116.72	127.14	138.02	149.34	161.10	173.32	185.97	199.08	212.63	226.63	241.07	255.96	271.29	287.07	
15/16	88.66	97.78	107.35	117.35	127.81	138.71	150.06	161.85	174.09	186.78	199.91	213.49	227.51	241.99	256.90	272.27	288.07	

The weights in this table are based on one cubic inch of steel = 0.2833 lb.

For materials other than steel use the multipliers in the accompanying table.

MATERIAL	WGT PER CUB. IN	MULTIPLIER
Wrought iron	0.2779	0.9810
Cast iron	0.2604	0.9191
Yellow brass	0.3029	1.069
Copper	0.3210	1.134
Lead	0.4106	1.449
Aluminum	0.0963	0.3399
Glass	0.0945	0.3338

EXAMPLE: What is the weight of a solid cast iron cylinder, $27\frac{5}{16}$" dia x 120" long?

SOLUTION: In the table, vertically under 27", and horizontally opposite $\frac{5}{16}$, read 166.39 lb

The required weight = 166.39 × .9191 × 120 = 18351 lb.

1	Aug. 3.05

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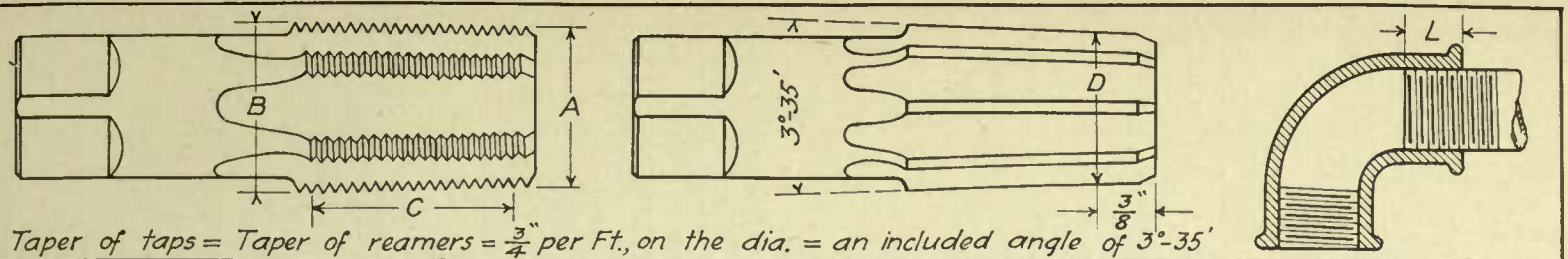
87168

FIG. 41. SAMPLE PAGE FROM WESTINGHOUSE BOOK OF STANDARD DATA SHEETS.

W.I. PIPE : TAPS & REAMERS.



Taper of taps = Taper of reamers = $\frac{3}{4}$" per Ft., on the dia. = an included angle of 3°-35'

PIPE DIAMETERS			THREADS		TAP & REAMER				L	PIPE DATA					
Nominal.	Actual		Nbr per INCH	Tap drill Dia.	A	B	C	D $\frac{3}{8}$" from end	Approx. GRIP	Thickness of Wall	Internal Area in Sq. In.	Feet length that will just contain one cubic Ft.	Feet length of pipe per sq. Ft. inside surface	Feet length of pipe per Sq. Ft. outside surface	Weight in lb. per foot of length
	Inside	Outside													
1/8	0.270	0.405	27	21/64	0.370	0.412	11/16	11/32	1/4	0.068	0.057	2513.00	14.151	9.434	0.24
1/4	0.364	0.540	18	29/64	0.478	0.551	1 1/16	7/16	1/4	0.088	0.104	1383.30	10.500	7.075	0.42
3/8	0.494	0.675	18	19/32	0.615	0.679	1	9/16	1/2	0.091	0.191	751.20	7.732	5.658	0.56
1/2	0.623	0.840	14	23/32	0.767	0.846	1 3/8	43/64	1/2	0.109	0.304	472.40	6.132	4.547	0.84
3/4	0.824	1.050	14	15/16	0.977	1.057	1 3/8	57/64	1/2	0.113	0.533	270.00	4.635	3.638	1.12
1	1.048	1.315	11 1/2	1 3/16	1.215	1.321	1 13/16	1 1/8	5/8	0.134	0.861	166.90	3.645	2.904	1.67
1 1/4	1.380	1.660	11 1/2	1 15/32	1.568	1.675	1 7/8	1 7/16	5/8	0.140	1.496	96.25	2.768	2.301	2.24
1 1/2	1.611	1.900	11 1/2	1 23/32	1.853	1.956	1 3/4	1 23/32	5/8	0.145	2.037	70.66	2.353	2.010	2.68
2	2.067	2.375	11 1/2	2 3/16	2.270	2.381	1 13/16	2 3/16	3/4	0.154	3.356	42.91	1.848	1.608	3.61
2 1/2	2.468	2.875	8	2 11/16	2.735	2.910	2 1/2	2 37/64	13/16	0.204	4.780	30.10	1.548	1.329	5.74
3	3.067	3.500	8	3 5/16	3.319	3.557	2 1/2	3 13/64	7/8	0.217	7.383	19.50	1.245	1.091	7.54
3 1/2	3.548	4.000	8	3 13/16						0.226	9.887	14.57	1.077	0.955	9.00
4	4.026	4.500	8	4 7/32						0.237	12.730	11.31	0.949	0.849	10.66
4 1/2	4.508	5.000	8	4 21/32						0.246	15.961	9.02	0.847	0.764	12.49
5	5.045	5.563	8	5 15/64						0.259	19.986	7.20	0.757	0.687	14.50
6	6.065	6.625	8	6 1/4						0.280	28.890	4.98	0.630	0.577	18.76
7	7.023	7.625	8	7 5/16						0.301	38.738	3.72	0.543	0.501	23.27
8	7.982	8.625	8	8 5/16						0.322	50.039	2.88	0.478	0.543	28.18
9	8.937	9.625	8	9 5/16						0.344	62.730	2.29	0.427	0.397	33.70
10	10.819	10.750	8	10 5/16						0.366	78.838	1.82	0.381	0.355	49.00

1 July 11.05

WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG, PA.

88090

FIG. 42. SAMPLE PAGE FROM WESTINGHOUSE BOOK OF STANDARD DATA SHEETS.

STOCK SIZES OF MACHINE BOLTS.

LENGTHS

DIA.	3/8	1/2	5/8	3/4	7/8	1	1/8	1/4	3/8	1/2	5/8	3/4	7/8	2	1/4	1/2	3/4	3	1/4	1/2	3/4	4	1/4	1/2	3/4	5	1/4	1/2	3/4	6	1/4	1/2	3/4	7	1/4	1/2	3/4	8	1/4	1/2	3/4	9	1/2	10	1/2	11	1/2	12	1/2	13	1/2	14	1/2	15
1/4				5/8	3/4	3/4		3/4		3/4 ●				●		1 ●		1 ●	1	1 ●		●		1 ●		●		1 ●		●		●		●		●		1 ●																
5/16				5/8		3/4		3/4		3/4 ●	3/4	3/4		●	1	1 ●		1 ●		●		1 ●	1	●	1	1 ●		●		●		●		●		●		●																
3/8						7/8		7/8		7/8 ●		1	1	1 ●		1 ●	1	1 ●		●		1 1/4 ●		1 1/4 ●		1 1/4 ●	1 1/4	●		1 1/4 ●		●	1 1/4	●		●	1 1/4	1 1/4 ●				●		●		●		●						1 1/2
1/2						1		1		1 ●		1		1 ●	1	1 ●		1 ●		1 1/4 ●		1 1/4 ●		1 1/4 ●	1 1/4	1 1/4 ●	1 1/4	1 1/4 ●		1 1/4 ●		1 1/4 ●		1 1/4 ●		1 1/4 ●		1 1/4 ●		1 1/4		1 1/2 ●	1 1/2	●		1 1/2 ●		●		1 1/2 ●		1 1/2 ●		●
5/8						1				1 1/4 ●		1 1/4		1 1/4 ●	1 1/4	1 1/4 ●	1 1/4	1 1/2 ●	1 1/2	1 1/2 ●	1 1/2	●		1 1/2 ●	1 1/2	●		1 1/2 ●		1 1/2 ●		1 1/2 ●	1 1/2	●		●		1 1/2 ●				1 1/2 ●	1 1/2	1 1/2 ●		1 1/2 ●		1 3/4 ●		2 ●		●		2 ●
3/4										1 ●				1 1/4 ●		●	1 1/2	1 1/2 ●		1 1/2 ●	1 1/2	1 1/2 ●		1 3/4 ●		●		●		●		●		●	1 3/4	●		1 3/4 ●				2 ●	2	2 ●	2	2 ●	2	2 ●	2	●		●		2 ●
7/8										1 ●				1 3/4 ●		●	1 3/4	1 3/4 ●		●		1 3/4 ●	2	●		●		●		●		●		●		2 ●		●				●		2 1/4 ●	2 1/4	●	2 1/4	●		●		●		●
1														●		●		1 3/4 ●		1 3/4 ●		●		2 1/4 ●		●		●		●		●		●		●		●				●		●		●	2 1/2	●	3	3 ●		●		●
1 1/4																		●		●		●		●		●	2 1/2	●	3	●		●		●		●		●				●	3 1/4	●		●		●		●		●		●
1 1/2																														3 1/2																								
1 3/4																																												4										
2																																																						

THREAD LENGTHS.

Sizes marked ● are kept in stock by manufactures and are therefore preferable when new lengths are required.

Where the thread length is entered, the bolt thus indicated is kept in stock in our storerooms.

EXAMPLE: Do we carry in stock a machine bolt 3/4" dia x 7 1/4" long, and what is the length of the thread?

Reading opposite 3/4" (in the column headed DIA.) and under the length 7 1/4" we find entered 1 3/4; this 1 3/4" is the thread length, and the fact that it is entered here means that the bolt required is in stock.

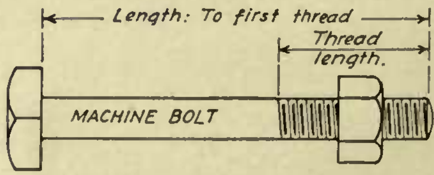


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FIG. 43. SAMPLE PAGE FROM WESTINGHOUSE BOOK OF STANDARD DATA SHEETS.

one item to another. Without guide lines it is easy when reading across a page of columns to get on to the wrong line. In Fig. 41 modifications of the same features are used; the vertical columns in the lower half of the table are purposely staggered in relation to those in the upper half, and heavy-dash guide lines are again employed. In Fig. 42 the *headings* are the principal feature; they are arranged in striking "groups," and the rulings for them are made irregular—another example of staggering. The notable feature of Fig. 43 is the manner of indicating the bolt lengths in the horizontal head line, $\frac{3}{8}$ to 15, after the fashion of a graduated scale; here also the use of guide lines is an important feature, heavy horizontal and vertical lines being introduced at such intervals as to make it easy to refer quickly to any required size of bolt. But perhaps enough has been said to show that in making up sheets of this kind there is room for the exercise of a great deal of care and ingenuity.

155. It is the writer's hope that the engineering profession will adopt the size and style of standard sheet presented here—or some other on similar lines—and that the time will come when the valuable data now worked out or collected, and put together for the rather selfish use of individuals or single firms, will be generously distributed, through some such channel as *Engineering News*, for the benefit of the entire engineering fraternity.

CHAPTER XII. EXAMPLE DRAWINGS.

156. Figs. 44 and 45 are reproductions of actual working drawings belonging to the type that this dictionary is intended to govern—the "illustrated specification." They are introduced here merely as examples of the writing of the language, and not because they deserve any special study or teach any particularly valuable lesson in themselves. Their purpose is to illustrate in a general way the dictionary features covered in the preceding chapters.

157. The only way that any man can hope to become a draftsman of the highest type is to make drawings; an examination of the drawings made by somebody else can do him very little good. It is a comparatively easy matter for any draftsman or drafting room to adopt such drawing features as are purely mechanical—the alphabet of lines, styles of lettering, figures and dimensions, projection, sectioning, the finish mark and the record strip—but it is only by the persistent exercise of care, common sense, and good judgment in the actual making of drawings that the individual can develop into the high-class draftsman.

158. In Fig. 45 certain pieces are "item numbered" and the drawing carries a list of the items in the form of a "bill of material," as it is generally called. Some such list is often used in the modern drafting

2005

SPECIFICATION

GENERAL: This drawing table is to contain 6 lock drawers, a rack to hold 5 drawing boards (size of boards 23"×31"×$\frac{1}{8}$") a swing pocket for filing drawings in envelopes (size of envelope 23"×31") and a slide to carry a file that is 12" long x 1" wide.

DIMENSIONS and CONSTRUCTION: Every dimension that is enclosed in a circle must be as specified. The manufacturer may use his discretion regarding other dimensions to insure good construction. The table must rest entirely on the 4 legs, with 2" floor clearance.

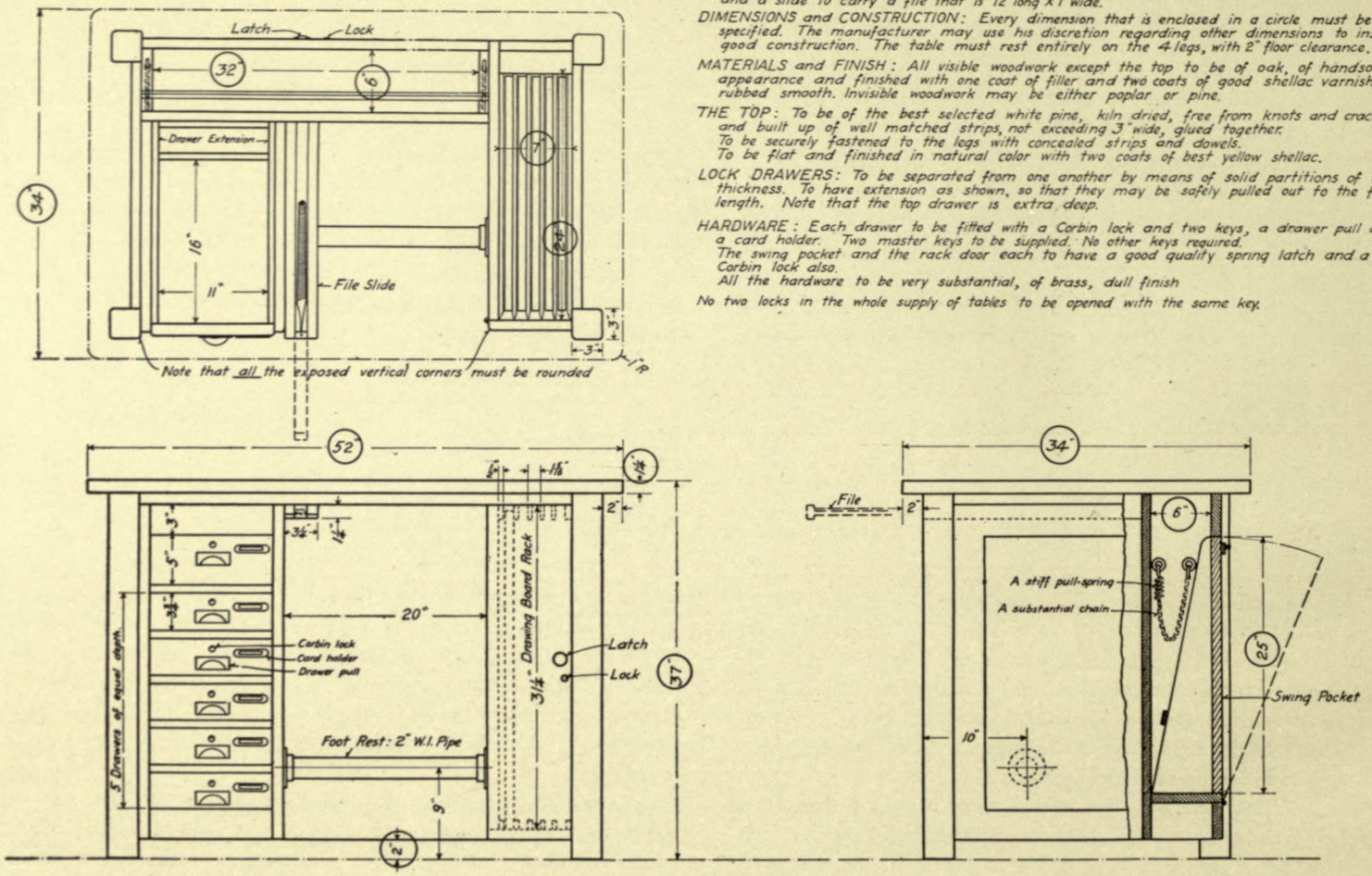
MATERIALS and FINISH: All visible woodwork except the top to be of oak, of handsome appearance and finished with one coat of filler and two coats of good shellac varnish, rubbed smooth. Invisible woodwork may be either poplar or pine.

THE TOP: To be of the best selected white pine, kiln dried, free from knots and cracks, and built up of well matched strips, not exceeding 3" wide, glued together.
To be securely fastened to the legs with concealed strips and dowels.
To be flat and finished in natural color with two coats of best yellow shellac.

LOCK DRAWERS: To be separated from one another by means of solid partitions of suitable thickness. To have extension as shown, so that they may be safely pulled out to the full length. Note that the top drawer is extra deep.

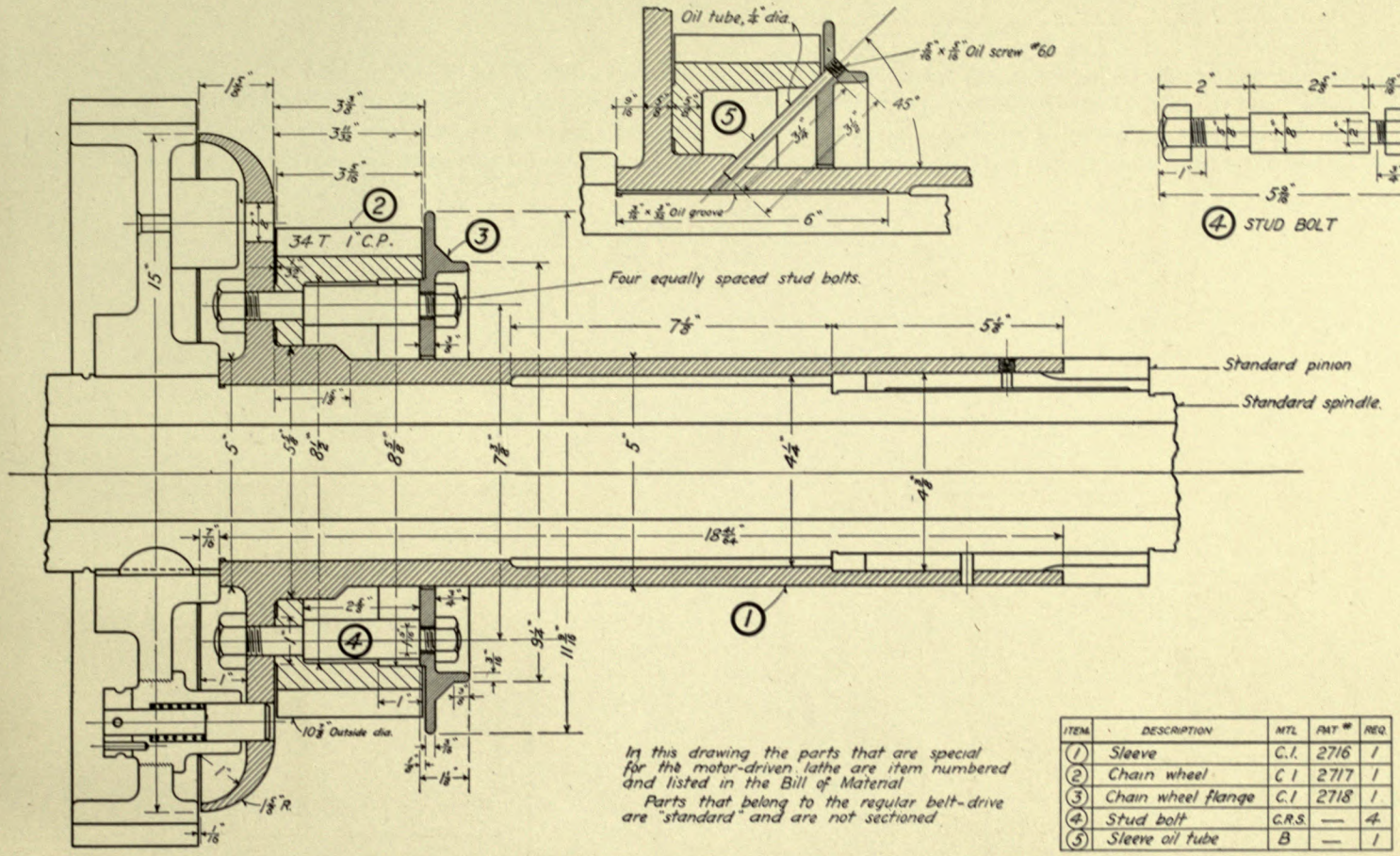
HARDWARE: Each drawer to be fitted with a Corbin lock and two keys, a drawer pull and a card holder. Two master keys to be supplied. No other keys required.
The swing pocket and the rack door each to have a good quality spring latch and a Corbin lock also.
All the hardware to be very substantial, of brass, dull finish

No two locks in the whole supply of tables to be opened with the same key.



2005	THE CARNEGIE TECHNICAL SCHOOLS, Pittsburgh, Pa., U.S.A.	Scale: ⅛ B-2005
Draftsman: Neederhof June 1. 06 Tracer: Chambers June 2. 06 Checker:	1 First Order OK. [illegible]	SINGLE DRAWING TABLE CABINET STYLE FOR THE SCHOOL OF APPLIED SCIENCE General Drawing

FIG. 44. AN EXAMPLE WORKING DRAWING OF THE "ILLUSTRATED SPECIFICATION TYPE."



In this drawing the parts that are special for the motor-driven lathe are item numbered and listed in the Bill of Material. Parts that belong to the regular belt-drive are "standard" and are not sectioned.

ITEM	DESCRIPTION	MTL	PAT #	REQ.
1	Sleeve	C.I.	2716	1
2	Chain wheel	C.I	2717	1
3	Chain wheel flange	C.I	2718	1
4	Stud bolt	C.R.S.	—	4
5	Sleeve oil tube	B	—	1

ITEMS 1, 2 & 3 : Finish all over.

28013	THE LODGE & SHIPLEY MACHINE TOOL COMPANY, Cincinnati, Ohio, U.S.A	Scale ½ 28013
Draftsman: June 21 06	1 1st Order No. 6320	24" MOTOR-DRIVEN LATHE
Tracer: June 24 06		CHAIN WHEEL SPINDLE SLEEVE
Checker:		DETAIL ASSEMBLY.

FIG. 45. ANOTHER EXAMPLE WORKING DRAWING WITH BILL OF MATERIAL.

room, the form and contents depending, of course, upon the nature of the work specified, and the kind of information required by the shop. The only reason for directing any attention here to the bill of material is to advise against the practice of using ditto marks in any such lists on drawings. The bill of material is in effect a collection of independent specifications, and each specification should therefore be independently complete; otherwise it will happen that a change intended to affect only one item will go through as affecting all those ditto marked under it.

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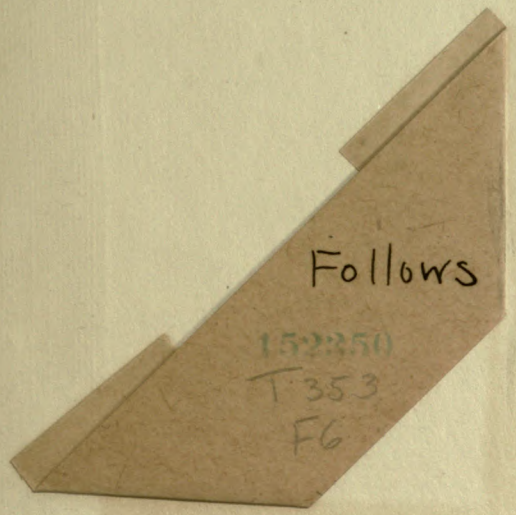
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